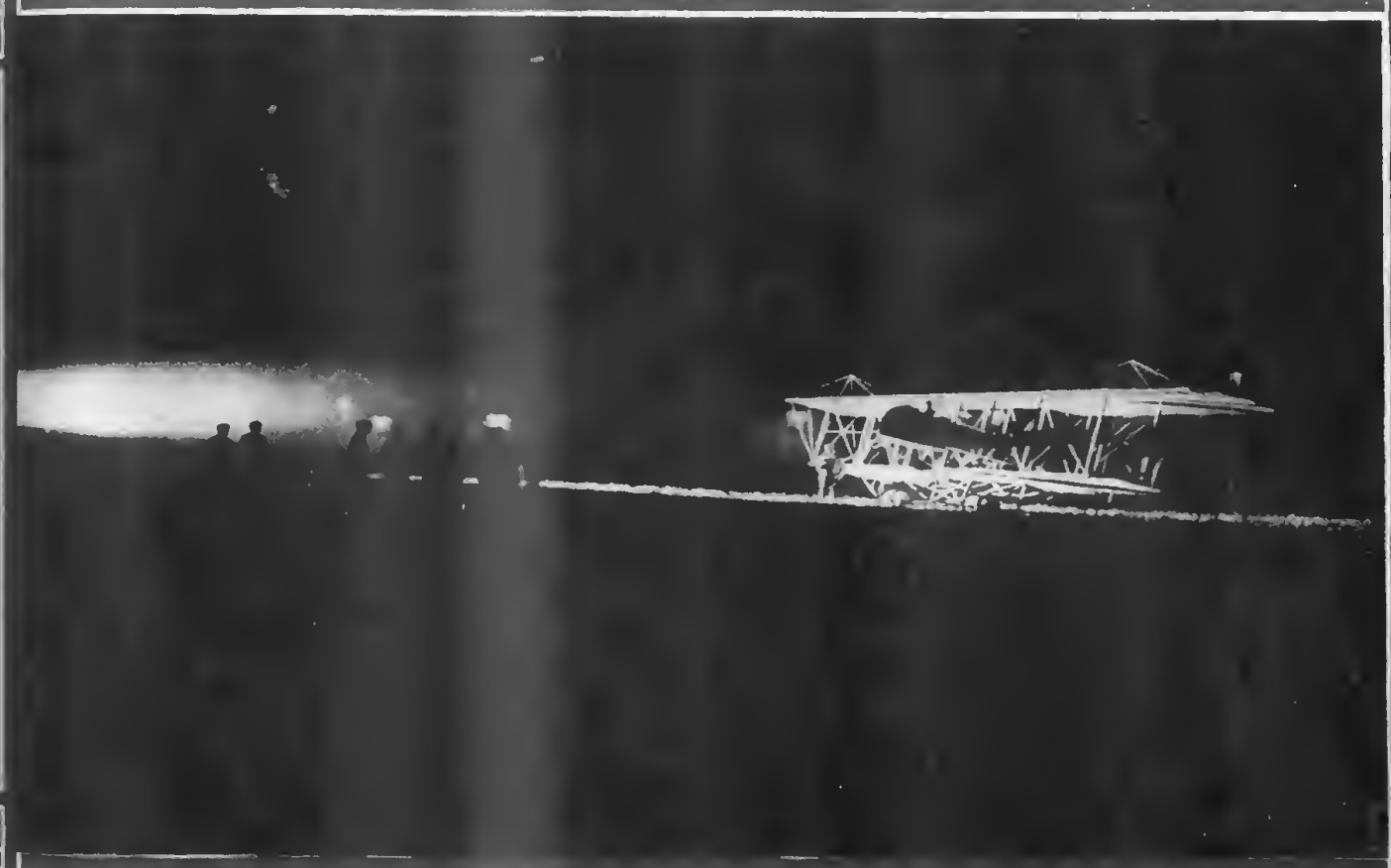
AVIATION
AND
AERONAUTICAL ENGINEERING



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A French Airplane Landing at Night, with the Aid of a Searchlight

MAY
15th
1917

SPECIAL FEATURES

THE ARMY PLAN FOR TRAINING AVIATORS

MILITARY AIRPLANE PHOTOGRAPHY

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THE HANDLEY PAGE GIANT BIPLANE

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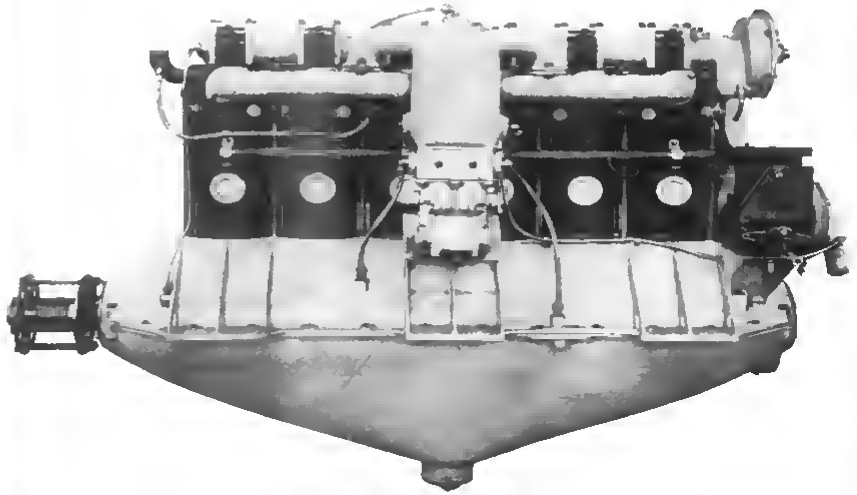

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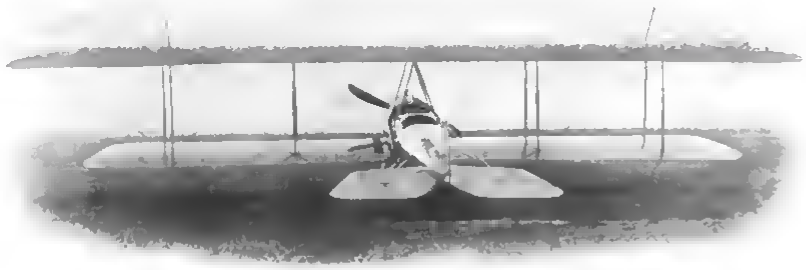

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GENERAL DIMENSIONS

Wing span, upper plane	44' 10"
Wing span, lower plane	34'
Depth of wing (cord)	6'
Gap between wings	5' 7"
Stagger	43½"
Overall length of machine	30' 5"
Overall height of machine	10' 10"
Angle of incidence	3½°
Dihedral angle	3°
Sweepback	5°
Wing curve	R.A.F. No. 3
Horizontal stabilizer, angle of inclination	0°

WEIGHT

Net weight—Machine empty, including water ballast, service, but without fuel	1350 lbs
Gross weight—Machine loaded	1950 lbs

AREAS

Upper wing	254 sq. ft.
Lower wing	146 sq. ft.
Total supporting surface (wings and ailerons)	420 sq. ft.
Ailerons (each 5.1 sq. ft.)	32 sq. ft.
Stabilizer—horizontal	17 sq. ft.
Stabilizer—vertical	1.7 sq. ft.
Elevators (each 11 sq. ft.)	22 sq. ft.
Rudder	10 sq. ft.
Max. load per sq. ft. Sup. Surface	4.4 lbs.
Max. load per H. P.	10 lbs.

PERFORMANCE

Max. Speed—Full load	68 M.P.H.
Min. Speed—Full load	37 M.P.H.
Climbing Speed in 10 minutes	2000 ft.
Range of Action at cruising Speed	350 miles
Climbing angle	1 in 8

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MAY 15, 1917

AVIATION
AND
AERONAUTICAL ENGINEERING

VOL. II. NO. 8

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THE GARDNER, MOFFAT COMPANY, Inc., *Publishers*
120 WEST 32D STREET NEW YORK

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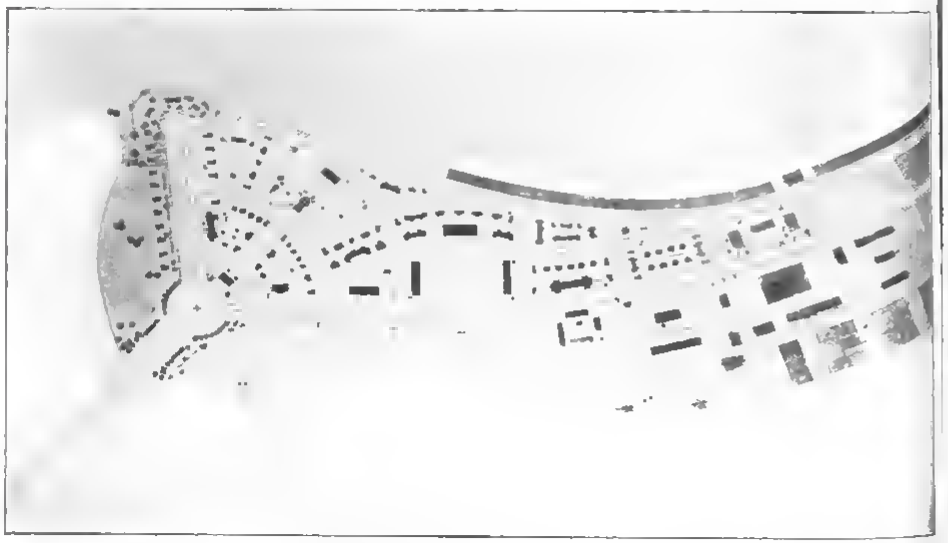
LANGLEY FIELD

The tentative plans for Langley Field, the aviation headquarters of the Army, to be located at Hampton, Virginia, as designed by the architect, Albert Kahn of Detroit, are shown here for the first time. These reproductions do not do full justice to the elaborate plans, but will give a general idea of the scope of the project. Facing the bridge is the Administration Building, surrounded by quarters for the officers and civilians. The drill ground is ample for military instruction. At the lower right are the large airplane hangars. The airplane hangars face the flying field and are planned so that ship can be extended as may be required. The laboratories, wind tunnel, experimental aircraft shops and buildings of the National Advisory Committee for Aeronautics are located centrally between the groups of hangars.



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*Absent on duty, Aviation Section, U. S. A.

AVIATION AND AERONAUTICAL ENGINEERING

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A KLEMIN A C G I , B Sc , S.M
Instructor in Aeronautics
Massachusetts Institute of Technology
BUSINESS MANAGER
GEORGE NEWBOLD

Vol. II — May 15, 1917 — No. 8

THE plans that have been prepared for Langley Field indicate that aviation is to have a veritable West Point. The site seems to lend itself to architectural treatment of the most elaborate character, and great praise is due the architect and those who cooperated with him for the comprehensive plan which has been submitted.

What may be the development from the extensive experimental work to be conducted at the field the future alone can show. If the automobile early in its history had been subsidized with millions of dollars of Government appropriations and there had been detailed to its improvement and refinement the best trained minds of the Army and Navy, how much more quickly would the moderate priced reliable vehicle of today have been produced. The airplane, requiring as it does the skill of aeronautical engineers and motor experts, would have developed slowly had it not been for governmental support. With all the research and experimental work centered at one place the science of aeronautics will immediately receive an impetus which will place the United States in a position to produce advanced types which should lead the world.

It is becoming more and more evident to those who are considering the future of the aeronautical requirements of the Government that it is inefficient to have both the Army and Navy working along parallel lines in building up two separate air services. Langley Field may be one of the means of showing to those in authority that this country can best be served by one centralized aeronautical service.

The Cadet Course

The unparalleled rush of young men from all parts of the country to enter the aviation section has brought with it problems that are not easily solved. The general impression of most of the applicants is that they can immediately rank as officers and will learn to fly in the same way that they learned to operate an automobile. The need has been so pressing that this procedure has almost been the case. But with experience as a guide and the lack of sufficient equipment as a fact to consider a more carefully planned program of tuition can be undertaken. The announced cadet course to be given at the six educational institutions selected is a step in the right direction.

Before any young man should be allowed to operate the controls of valuable Government airplanes even with the most experienced instructors, he should have been tested both physically and mentally and the obviously unfit eliminated. It is true that under the press of necessity many aviators flying abroad could not pass some of the tests required. One of the most brilliant of the French flyers is reported to be a hopeless consumptive, yet he has achieved results that are unparalleled. But these are exceptional cases.

The military or naval aviator to be of the greatest value to the Army or Navy must have a physique that will withstand the exacting demands of air manoeuvering, must have the training and intelligence to be able to observe as well as to fight, and must be grounded in the tactics of the air as well as the operation of a machine.

The cadet course will act as a sieve which will automatically retain for the service the capable and the promising.

The National Advisory Committee

On another page of this issue will be found a statement of the organization, duties, work already accomplished and now under way by the National Advisory Committee for Aeronautics.

The Committee deserves the hearty support and cordial cooperation of the entire aeronautical industry. Its efforts in assisting to solve some of the most important problems, including that of patents, deserve high praise.

With the completion of its new field experimental station, which will include a testing laboratory, wind tunnel and machine shops, the Committee will be able to make still more valuable contributions to the practical solution of aeronautical problems, and these contributions will be available to the entire industry.

The Work of the S. A. E. Standards Committee

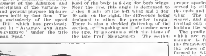
Working in close cooperation with the Army and Navy, the Standards Committee of the S. A. E. through its aeronautic division, has made important recommendations for the adoption of fixed standards in many details of construction of machines. It is significant to find that many of the large constructors are cooperating in this work.

Adoption of standards, which will enable an increased production of machines to be made, will not only be of benefit to the industry, but is necessary if the country is to take an important and commanding part in the war. It is gratifying to see the earnest and harmonious efforts of the engineers and Government officers, working together for the solution of problems which must be solved if we are to make ourselves felt as a factor in the fight for freedom and democracy.

The Albatros Biplanes

By Jean Lagorgette*

The latest of the long series of interesting and instructive articles which M. Lagorgette has been contributing to *L'Aérophile* are two on the Albatros biplanes, which form a considerable part of the German aerial fleet. The first of these articles gives a historical summary of the development of the Albatros and a detailed description of the various reconnaissance and general purpose biplanes which have been built by that firm. The second treats exclusively of the speed scout model D I which has previously been mentioned in "AVIATION AND AERONAUTICAL ENGINEERING" under the title of the "German Spad."



1917 Model Albatros

The Albatros firm was founded in 1910 and its chief factory is at Johannisthal near Berlin. Its first activities were to build copies of the Farman and Antoinette and its distinctive work did not begin until in 1910 it acquired the services of the great German pilot Hellmuth Hirth. At the beginning of the war several world's records were held by the Albatros machines, notably those for altitude with three passengers (von Loessl 15,600 ft.) and duration (Böhm 24 hrs. 10 mins.).

All the Albatros machines in use in the war have been tractor biplanes and the changes in construction and design during the last two years have been much less radical than one might expect. In fact there has been manifested a marked tendency at many points where changes had been made, to revert to the practice of 1915.

THE MODEL C III

The reconnaissance 2-seater now in use is known as the model C III, and differs only slightly from the 1915 type. The wings are nearly equal in span, the span of the upper pair being 38 ft. 6 in., that of the lower 36 ft. 6 in., an overhang of only one foot at each end. The chord of the upper wings is 5 ft. 11 in., that of the lower 5 ft. 7 in. This difference in chord is something new in German machines and shows the influence of the Nieuport and other French designs. The areas of the upper and lower wings respectively are thus 213 and 191 sq. ft., a total of 404 sq. ft. The gap between the wings is 5 ft. 1 in., giving for the mean gap chord ratio the rather low value of 0.88. Unlike the earlier products of the Albatros firm, the C III has no sweep back of the wings, but there is a dihedral of 2 deg. There is no stagger and the front row of struts are vertical, but the back row are slightly inclined backwards due to the greater chord of the upper wings. There is left a decided gap (about 8 in.) between the two upper wings.

The wings have a rather deep camber, about .048 of the chord on the lower surface and .087 on the upper surface, and they are of virtually constant thickness from a point three inches back of the entering edge to the middle of the wing. The angle of incidence in the neighborhood of the body is 6 deg. for both wings. Near the tips, this angle is decreased to 3 deg. 6 min. on the left wing and 1 deg. 30 min. on the right, the difference being designed to allow for propeller torque. There is also a decided flattening of the section, or "washing out" of camber near the tips, in accordance with the ideas of the late Prof. Montgomery. The section with an upturned trailing edge which was employed on the 1917 model has ceased to be used.

Ailerons

As on many other German airplanes the ailerons are rather smaller than is usual in America. They are applied to the upper wing only and have an area of 18.1 sq. ft. each, making the aileron area only 8 per cent of the total wing area. They are warped as on most other German machines (v. AVIATION AND AERONAUTICAL ENGINEERING, Aug. 1, 1916), the object probably being to avoid the necessity of using the rudder in conjunction with the ailerons. The ailerons are attached, not to the rear spar proper, but to a third very much lighter spar, inserted chiefly for this special purpose.

Albatros C III, Side View

Struts and Wings

The spars are mounted extremely far forward in the wings. The front spar is but 4 in. from the leading edge and the distance between spars (in the upper wing) 2 ft. 8 in., leaving 2 ft. 11 in. overhanging the rear spar. There is, as mentioned above, a third spar some little distance in back of the two principal ones, but this is of minor importance. The proper spacing between the spars is preserved by elliptical steel tubes placed at the ends and middle of each panel of the wing. The ribs themselves are evenly spaced, and alternate with false ribs extending only as far as the rear spar and backing the web.

The profile of the ends of the wings, which are raked outward in the usual manner, is formed of steel tubes, as is the framework of the ailerons. The trailing edges of the wings themselves are formed by wires so that there is a slight scalloping between the ribs. The interplane struts, of which there are two pairs on each side of the body, are steel tubes of streamline section. The fittings which connect them to the wings and act as wiring plates are ingenious, but require the piercing of the wing spar by a bolt of considerable size. Wires run from the bottoms of the struts nearest the body to the upper part of the body instead of going directly to the top of the cabane as formerly. In this manner the interruption to the field of machine gun fire is minimized.

The wings are attached to the body and cabane by readily detachable screw fittings and are held secure against vibration by locking pins and keys. Steel tubes are fixed rigidly transversely of the body to provide a base to which the wing spars may be attached. The interior bracing of the wing is as usual of plated piano wire without turnbuckles.

Tail

The tail is of the lifting type, the stabilizer being set at an angle of 2 deg. 4 min. It is roughly semi-circular in shape and has an area of 32 sq. ft. The elevator comprises two flaps of conventional form, having an area of 14 sq. ft. The tail is decidedly changed in appearance from that on earlier models of the same make, where the stabilizer was triangular and the elevator flaps were parallelograms. The fin is triangular and is located partly above and partly below the body. It has an area of 7.7 sq. ft. The rudder is more nearly semi-circular than on previous productions, but its area remains unchanged at 8.7 ft. The framework of the tail is entirely of steel tubes.

* Abstracted by F. P. Warner from *L'Aérophile*

Body

The body of the model C III has the knife-edge at the rear horizontal, whereas all earlier Albatros machines have had it vertical. The body really terminates in a T since the fin below the body is built up integrally with it as a rigid keel. The fore-and-aft curvature nearly all comes on the lower surface of the body, the upper surface being comparatively flat in that plane. The length of the body exclusive of the cowl is 25 ft. 4 in., and its maximum cross-section is 3 ft. 2 in. high by 2 ft. 11 in. wide. The engine is carried on two bearers of pine of I section and these in turn rest on heavy partitions of three-ply wood, inserted in the body for this purpose, and taking their bearing directly on the landing gear struts. The pilot sits between the wings, the observer and gunner just back of the trailing edges.

The body is built up around four principal longerons lying in the corners and

Albatros C III Showing Warping of Ailerons

two subordinate longerons lying midway up the flat sides. These members are all of spruce, except that the uppermost pair forward of the splice, which comes just in back of the observer's seat, are of ash. There are three partitions of three-ply wood which serve for cross-braces, and these, aside from the light struts which serve to maintain the longerons at their proper spacing, are virtually all the bracing that there is in the body. There is not an inch of wire in the structure. The body is covered with three-ply wood, making, in conjunction with the longerons and formers, an exceedingly strong structure and one which is not excessively heavy.

Landing Gear

The landing gear possesses no very unusual features except the spring brake which is mounted between the wheels, and which is shown in one of the illustrations. The track is 6 ft. 1 in. and the wheels are 31x5 tires. The axle is a simple steel tube a little more than two in. in diameter. When in flight it lies directly behind the fixed tube connecting the two Vs, but no attempt has been made to have it house itself in a streamline casing. The body struts are also steel tubes and are connected to the body at their upper ends by a neat and simple fitting which makes contact with the body longerons around two sides and also makes due provision for the attachment of the turnbuckles which terminate the external drift wires and the landing gear bracing wires. The landing gear is cross-braced only in the plane of the forward members of the Vs.

The brake is, as previously mentioned, mounted between the wheels and above the axle. It is operated by a lever accessible to the pilot's left hand.

The tail skid is entirely outside of the body, and is mounted through the intermediary of a pivoted fork, at the vertex of a pyramid of four steel tubes. This pyramid, however, is hardly symmetrical, the rear pair of tubes being vertical while the forward pair are in consequence considerably inclined. The skid itself is of ash. It is sprung by two independent clusters of rubber rings connected to the body on each side of the longitudinal axis, thus interposing a resistance to any excessive side thrust and swivelling.

Power Plant

The engine is a Mercedes, either a six cylinder 170 h.p. or more rarely an eight cylinder 220 h.p. The six-cylinder type drives the propeller direct at 1450 r.p.m. but the larger engine uses a geared-down propeller.

A Garuda propeller 9 ft. 2 in. in diameter is used. The maximum blade width is 7½ in. and both blades are bent forward from the hub as is shown by the side elevation of the machine. The propeller is made of walnut and mahogany laminations.

The main gasoline tank is under the pilot's seat and holds 66 gals. On the most recent examples of the C III which the French have captured, the tank is divided into two compartments, the smaller of which holds 8 gals., providing enough fuel for the aviator to regain his own lines. Provision is made for filling the tank from outside the body.

The gravity feed tank is above the upper wings and is of streamline form. It holds 10 gals. The oil tank is at the left of the engine and is held in position by leather straps. The capacity of this is 5 gals.

The exhaust stack discharges above the upper wings as has been the usual practice in German airplanes. It is of elliptical section 4 in. by 4¾ in.

A honeycomb radiator is used and it is located above the upper wings. A small tube runs from the upper portion of the radiator to the water jacket of the rear cylinder, thereby preventing the establishment of air-locks in the water circulation.

Controls

The elevator is controlled by the fore-and-aft motion of a lever. The control wires are both attached to the lever above the pivot, one running directly back to the elevator, the other running forward around a pulley and thence to the elevator. When the elevator is in position for level flight the lever is not vertical but is inclined forwards.

The ailerons are controlled by a side-to-side movement of the same lever which operates the elevator. The aileron wires run through the interior of the lower wing until they are vertically under their ultimate point of attachment, when they pass around a pulley and so into the vertical plane.

The foot-bar which operates the rudder is mounted on the vertex of a pyramid made up of three steel tubes. The axis about which it turns is inclined forward at a considerable angle so that the pilot may secure a more direct thrust against the bar in the plane of motion. The wires are attached at the same point to a framework which juts out forward from the foot bar. They then run around pulleys and thence to the rear, inside the body. Notches are cut in the body formers to guide the wires and keep them from vibrating.

Equipment

As befits an all around machine, the equipment of the Albatros C III is extensive. Wireless instruments and an aerial camera are carried in addition to all the usual instruments. Provision is made for lighting the instrument board during night flights. An interesting detail is the telephone for facilitating communication between pilot and passenger.

M. Lagorgette declares that the lateral stability of the machine is excellent, but that the longitudinal stability is defective, a tendency to go into nose-dives being marked.

The weight of the machine empty, but with water in the radiator, is just under 1900 lb. The tank capacity is sufficient to permit flights of four and a half hours duration, and the useful load, fuel not included, is 660 lb., making a total weight when in flight of roughly 3000 lb. The loading is 7.4 lb. per sq. ft., and 17.6 lb. per horsepower.

The Albatros C III has a maximum speed of 87 m.p.h. at a low altitude and 84 m.p.h. at a height of 6,500 ft. It is capable of climbing 1000 m. (3280 ft.) in 9 mins. and 2000 m. (6560 ft.) in 22 mins. The maximum altitude attainable is 12 100 ft. with full load or 16 100 ft. with the fuel load reduced to a minimum.

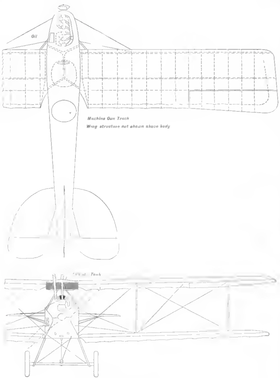
THE SPEED SCOUT

The wings of this machine, which is a comparatively new production, all the examples captured having appeared since Dec. 1, 1916, have neither sweep back nor dihedral. They are normally exactly superposed but can be staggered about five inches by means of five sets of holes in the cabane. The spars of the upper wing can be bolted to any one of these five sets, thus regulating the degree of stagger.

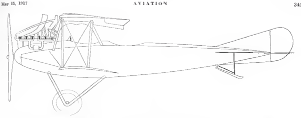
Landing Gear of Albatros C III. Note Brake

The span of the upper wings is 28 ft. 4 in., that of the lower pair 26 ft. 5 in., the overhang thus being, as on the C III, scarcely appreciable. The chord of each wing is 5 ft. 4 in., and the areas of the upper and lower wings respectively are 145 sq. ft. and 118 sq. ft., a total of 263 sq. ft. The angle of incidence is 5 deg. 3 min. in the vicinity of the longitudinal axis of the machine and the wings are so warped that the angle is diminished to 4 deg. at the tip of the left wing, 2 deg. at the tip of the right.

The ailerons are on the upper wing only, and are warped as in the C III. They are supported at the hinge by a third auxiliary wing spar, also as in the case of the



Plan View of the Albatros C III



Side Plan View of the Albatros C III

C III. Their area is 10.8 sq. ft. each or a total of 8 per cent of the total wing area.

The structure of the wings is, in general, similar to that of the other Albatros machines, although the section is much thinner and the camber is somewhat less.

Albatros Speed Scout

A notable feature is that the upper wing is made in one piece only, and is simply bolted to the cabane by two bolts which pierce the principal wing spars.

There is but one pair of interplane struts on each side. The wiring is simple, the only wires exterior to the wing cell being two drift wires which run from the nose of the body to the top of the rear strut on each side.

The Tail and Control Surfaces

As in the model C III. the body terminates in a T, with a solid keel below the horizontal knife-edge. The position of the vertical surfaces is remarkably far forward, both fin and rudder lying entirely in front of the rear of the body. The rudder thus lies completely above the body. The keel, however, provides some vertical fin surface below the body. This placing of the vertical surfaces makes it possible to make the elevator in one piece. Both elevator and rudder are balanced by triangular pieces at their extremes which run out in front of the axis of rotation. The surfaces are all roughly symmetrical and rounded, even the fin having lost its traditional triangular shape. Unlike that of the C III., the stabilizer is set at a zero angle to the line of flight. The most noteworthy feature of the structure is its extreme thickness especially in respect of the horizontal surfaces, which makes it possible to entirely dispense with exterior bracing. The frame is of wood, a variant from the preponderance of recent German practise. The areas are as follows: stabilizer, 15 sq. ft., fin (including keel below body), 8.5 sq. ft., elevator 12 sq. ft., rudder 6 sq. ft.

Body

The structure of the speed scout's body is practically identical with that of the C III. and, as in the case of the larger machine, there is no wire or other adjustable cross bracing whatever. The length is 21 ft. 4 in. and the largest cross section is 4 ft. 1 in. high by 3 ft. 1 in. width, these dimensions being materially greater than those of the C III.

The landing gear is identical with that of the C III., except that the track is 2 in. less, the wire cross-bracing lies in the plane of the after struts instead of that of the forward, and there is no brake.

The tail skid is more nearly horizontal than on the two-seater type and is attached to the keel below the body, instead of having a separate pyramid of tubes built up to support it.

Power Plant

The engine is a 170 h.p. Mercedes, and drives a propeller 9 ft. 2 in. in diameter, for which $\frac{V}{ND}$ is 1.11, permitting the attainment of a very high efficiency. The propeller hub is capped by a conical piece, completing the streamline form of the body.

The exhaust pipe is directed downwards and towards the rear along the right side of the body, an unusual feature in German machines. The radiators, two in number, are placed one on each side of the body. They are very small and of slightly different form, that on the left being the larger. They are supplemented by a water tank just above the camshaft.

Controls

The general type of control system is similar to that on the two-seater, but there are interesting variations and additions. The elevator lever has attached to it a linkage forming a parallelogram, and a friction device incorporated with this linkage makes it possible to lock the lever at any point.

Head View of Speed Scout. Note Smooth Lines of Tail and Small Radiators on Sides of Body

Course in Aerodynamics and Airplane Design*

By Alexander Klemin, A.C.G.I., B.Sc., S.M.

Instructor in Aeronautics, Massachusetts Institute of Technology, Member of the Aeronautical Society of Great Britain and Ireland,

and

T. H. Huff, S.B.

Instructor in Aeronautics, Massachusetts Institute of Technology

PART II—SECTION 7

Preliminary Design of a Secondary Training Machine

Preliminary Weight Estimates

Every designer will approach the design of a new machine in a different manner, and no definite rules can be laid down. In the design of a standard secondary training machine, we have the advantage of following well-known lines, with such excellent examples of machines tried out in practice as, for example, the Curtiss JN. Following such practice we can make very close estimates of possible weights and performances, and easily determine possible wing and control surfaces. A new and difficult type, such as a military twin-hydro, would require long preliminary study.

Recalling Army Specification No. 1001—detailed in *Part 2, Section 1*—we have to meet the following requirements:

Pilot and passenger 330 lbs.
Gasoline and oil for 4 hours flight
Engine between 90 and 110 h.p.
Maximum speed, 75 m.p.h.
Minimum speed, 43 m.p.h.
Climbing speed, 3000 ft. in 10 min.
Two wheel landing gear

From the engine data of *Section* 5 we could select a number of suitable engines. We shall select the Curtiss 90 h.p. OX. It is with this engine that a student has designed a similar machine, the salient features of which we shall embody in the post-graduate course at the Massachusetts Institute of Technology.

Practice shows that the above performances can be achieved with a weight of about 1850 lb., i.e. 20.4 lb. per horsepower, and we shall make this our preliminary estimate. This figure is slightly less than that of the JN-4, but is probably very near to the JN-4B.

The first step is to set down all weights of which we can be fairly certain, and on which an improvement is possible, thus:

		lb.
A B	Pilot and passenger in aviation dress	330
C	Engine and accessories	400
D	Radiator	50
E	Water in engine and radiator and piping	40
F	Propeller and hub	37
G	Gasoline tank of 40 gallons capacity	30
H	Gasoline and oil for 4 hours flight	220
I J	2 instrument boards, with a set of barograph, tachometer, air speed indicator and clock on each	40
K L	2 Dep controls	25
		1130

This leaves us with some 720 lb. available for the purely structural parts of the machine: chassis, complete body assembly, wings, interplane bracing, and tail surfaces. On the Curtiss JN-4 (*Part 1, Section 3*) we have the following percentages for these groups:

Chassis	4.03% equivalent in our machine to	74.5 lb.
Wings	14.15%	261.0
Interplane bracing	4.95%	91.5
Tail surfaces	2.76%	51.0
Body assembly equivalent to 286.0 lb. from which must be deducted 40 lb. for instrument boards and instruments, leaving	15.75%	246.0
		724.0

Since we are following standard practice very closely we can take the above figures to hold fairly well for various parts of the machine.

Choice of Wing and Area

For a machine of this type it is not necessary to have a wing of extreme characteristics. It is more practical to select a good all-round wing, with fair structural characteristics, than to choose a wing with high efficiency at low speeds but a low lift coefficient at maximum angles, and the R.A.F.6 can be adopted without much chance of mishap.

In a machine of the pursuit type, it would be worth while trying a number of different wing areas, but in a training machine it is, in the first place, essential to secure the necessary landing speed, and then to attain as high a speed and climb as possible with careful design. It only remains for us to find the maximum K_y of the R.A.F.6 and the necessary correcting factor for biplane effects.

There is, first of all, the question of stagger to be considered. The increased efficiency due to staggering is offset by questions of weight and head resistance, while the increase in efficiency is not so very important. Stagger is, therefore, mainly determined by considerations of the view obtainable by pilot or passenger. On this particular machine we shall employ a very slight stagger of about 7 per cent, giving a good overhead view for the pilot.

Overhang is likely to improve efficiency, but no aerodynamical data is available. It must be remembered that a large overhang, together with the aileron loads, imposes a very serious load on the rear spar of the wing. If any unsupported overhang is employed it should be less in length than the gap. We should, in the present state of the art, make no improvement in the K_y correction for biplanes on account of overhang.

We must also settle on gap chord ratio. We have seen in our aerodynamical work the improvement consequent on greater gap chord ratio. But to offset this, we have the question of increased weight and resistance of struts and wires. For triplanes with their blade-like wings, a very high gap chord ratio is, no doubt, permissible, but for biplanes the permissible limits are 0.9 to 1.2. We shall assume a value of 1.0 as a good conservative figure.

Under these circumstances, we need only correct our maximum K_y as for an orthogonal biplane with gap chord ratio of 1. The correcting figure for this as given in *Part 1 Section 8* is 0.81, but Dr. Hunsaker's experiments have shown that at maximum lift a better factor of 0.86 may be employed.

Since at high angles the tail surfaces will also be providing some lift, we may safely use this figure. Any obstruction between the wings, such as the body, will diminish the K_y, and in a twin-engined machine this effect would become quite serious, but it need not be considered for a single engine type. Constructors, in fact, using a correcting factor of 0.81 or 0.82 and neglecting the lifting effect of the tail surfaces have found their landing speeds surprisingly low.

The maximum K_y for the R.A.F.6 is 0.00310. Extending the equation $W = K_y A V^2$ to include the correcting factor of 0.86, we have when $V = 43$ m.p.h.

$$1850 = (0.0031)(0.86)A(43)^2$$

$$A = \frac{1850}{(0.0031)(0.86)(43)^2} = 376 \text{ sq. ft.},$$ which is taken to include the ailerons.

The questions of aspect ratio is again only partially dependent on efficiency, and a large aspect ratio introduces structural difficulties and tends to lateral instability. We shall assume an aspect ratio of 7 to 1 in both planes. If the planes

are slightly raked, the aspect ratio will be 7 for the mid line of the wings.

If x = chord in feet, $7x$ = span, and we have $14x^2 = 376$ and chord = 5 ft. 2 in. and span = 36 ft. 3 in.

We shall now fix purely on empirical grounds the length of the machine and the size of the control and fixed surfaces.

The designer is always tempted to shorten the length of the machine and to rely on a large stabilizer placed at a big negative angle, to secure static longitudinal stability. But in dynamical stability, it cannot be too strongly emphasized that damping is also essential, and damping improves rapidly with the length of the stabilizing arm. Too short a length would give rapid, undamped oscillations. The overall length of the Curtiss JN-4 27 ft. 3 in., is the outcome of several years' practical experience, and is probably a most suitable figure.

By empirical rules, such as outlined in *Part 2, Section 1*, the control surfaces may be fixed approximately at

Ailerons	57 sq. ft.	
Horizontal stabilizer	28 sq. ft.	[illegible] 1 deg. to the wings
Elevator	22.0 sq. ft.	
Rudder	12.0 sq. ft.	
Vertical fin	4 sq. ft.	

amount of longitudinal static stability. The propeller thrust passes through the center of gravity and does not, therefore, affect the stability in normal flight. Let us suppose that 4 deg. is the normal angle in flight, as it very probably would be. Then if the machine dives to 2 deg., the 2 deg. vector passing in front of the center of gravity will tend to pitch the airplane back to 4 deg. If the machine goes to a higher angle, say 8 deg., the vector will be behind the center of gravity and will give a counter clockwise moment about the center of gravity tending to restore it to 4 deg. again.

The next step is to see whether we can balance our machine about this point both in a vertical and in a horizontal plane. Before drawing up our three general arrangement views, we must go into a number of points connected with chassis design, but we can use the side view of Fig. 1 with slight modifications for our balancing up.

We shall employ the usual method for finding the center of gravity of a system consisting of a number of small bodies. That is, we choose a plane somewhere in the system as an axis and take moments about it, finally dividing the sum of the moments by the total weight of the members to find the equiva-

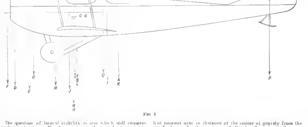


Fig. 1

The question of lateral stability is one which still requires much investigation. Purely on empirical grounds we can say that with no sweepback, but a fin of the above size with a dihedral between the wings of 2 deg. will secure a moderate lateral stability. For longitudinal stability to place the stabilizer at 3 deg. to the wings is a good setting prior to a wind tunnel test.

Position of Center of Gravity

In order to fix the position of the center of gravity, a vector diagram for the whole machine is necessary. But to draw a vector diagram, a wind tunnel model test is necessary and in the model we have already fixed the positions of the various parts of the machine. To draw a probable vector diagram without a model test is a most difficult matter. We have experiments to show the vectors for an orthogonal biplane alone, but with every different tail setting, body shape and landing gear we have a different vector diagram.

The best that can be done in preliminary design is, therefore, to make as shrewd a guess as possible, and to draw comparisons from as many model tests as possible. We have fortunately at our disposal the results of the tests on the Curtiss JN-2 which is almost identical with the design we are following. Eiffel 36 wings are used but in general arrangement the machine is almost identical with ours. In Fig. 1 is shown a side view of this machine, with the vector diagram of a wind tunnel test.

The center of gravity is indicated in the sketch, and lies on the 4 deg. vector. Such an arrangement will give an adequate

lent moment arm or distance of the center of gravity from the axial plane. In this case we shall take the axis at the rear propeller flange, that being the usual practice.

The following table illustrates the method in detail. The designations refer to Fig. 1, where the positions of the centers of gravity of the various elements are indicated.

Designation	Name of Element	Weight lb.	Dist. from propeller flange (ft.)	Moment about propeller flange (ft. lbs.)
A	Pilot	165	10.57	1743
B	Passenger	165	6.67	1100
C	Engine	400	2.50	982
D	Radiator	50	0.77	39
E	Water	40	2.20	84
F	Propeller	17	—0.17	—3
G	Gasoline tank	30	6.44	193
H	Gasoline and oil	220	6.44	1417
I	Rear instrument board	20	9.46	189
J	Forward instrument board	20	5.90	118
K	Rear control	12	10.57	127
L	Forward control	12	6.67	80
M	Chassis	74.5	4.50	142
N	Wings	261	6.32	1649
O	Interplane bracing	91.5	6.32	578
P	Tail	51	24.75	1262
Q	Body	246	9.11	2241
	Totals	1853		1210

Dividing the moment by the total weight of the machine, we see that the center of gravity of the machine is 6.53 ft. back of the moment axis. This brings it to a position virtually coincident with the tanks, and about one-third of the chord from the leading edges of the wings, which is virtually the position chosen from the vector diagram. If the center of

* This Course commenced in the August 1, 1916, issue of Aviation and Aeronautical Engineering

gravity does not come to the desired position at the first trial, it may be forced to do so by manipulation of the weights, shifting the engines, pilot, etc., slightly forward or backward, as the need may be.

A similar method, with moments taken about the ground line, is used to give the vertical position of the center of gravity. The actual work for this computation is omitted in order to avoid confusing the figure.

References—Part II, Section 7

Barnwell's Airplane Design.
"Experimental Analysis of Inherent Longitudinal Stability for a Typical Biplane."
National Advisory Report, 1915.

Important Notice

The author's purpose in carrying through the design of this machine has been to illustrate the fundamental principles involved rather than to design the best possible training machine. Thus in many cases, certain values and ratios have been adopted which are likely to be satisfactory, but might be improved by closer analysis. In the very first steps, a gap/chord ratio of 1 and an aspect ratio of 7 to 1 on both upper and lower planes have been adopted whereas closer analysis might have shown a bigger gap/chord ratio and some overhang to be preferable. It is believed that sufficient data has been provided in the first part of the course, to enable the student to understand the possibilities and to carry through the various modifications available. To have done this within the limits of the course would have been impossible.

Aeronautical Patents

Copies of these patents may be obtained for five cents each, by addressing the Commissioner of Patents, Washington, D. C.

ISSUED MAY 1, 1917

1,224,357 Filed May 1, 1912. To Frank A. Bullington, Portland, Ore. Mechanism for Controlling Airplanes.

ISSUED MAY 8, 1917

1,224,815 Filed March 4, 1915. To Lawrence L. Fosburgh, Sapulpa, Okla. Airplane.

1,225,069 Filed July 19, 1915. To John Waldimar Roben, Portland, Ore. Soaring Airplane.

1,225,139 Filed Oct. 16, 1916. To John Korzeniewski, Toledo, Ohio. Balloon.

1,225,711 Filed Dec. 22, 1916. To Alexander Albert Holle, Thames Ditton, England, assignor to the Variplane Co., Ltd.

Book Reviews

THE LONGITUDINAL INITIAL MOTION AND FORCED OSCILLATIONS OF A DISTURBED AIRPLANE

Reviewed by Prof. E. B. Wilson

The problems discussed are:

(1) The initial effect of a permanent change in the relative velocity of the air.

(2) The initial effect of an impulsive gust, of great intensity but acting only for a very short time.

(3) The forced oscillations produced by a periodic gust, undamped or damped, and the special case when the complex exponent representing the damped periodic gust is a solution of the period equation of the free oscillations of the airplane.

The machine for which the effects are figured is Bryan's skeleton airplane consisting of a main forward flat plane and a rear tail flat plane. The solution is expressed in terms of S_1, S_2, the respective areas of the planes, K_1, K_2, their coefficients of resistance, l, the distance between them, and so on.

Problems 1 and 2: The conclusions are that it is safest to make the velocity of the plane as large as possible while the angle of attack, the ratio tail/main plane and the ratio total area/load should be small in so far as consistent with stability.

Problem 3. The previous conditions still hold, but it is important not to get too close to the limit of stability and further, the tail should be fairly far behind the main plane.

The method of initial motions whereby the position of the machine is expressed in terms of series with the time as variable, is much shorter than the reviewer's method of actually integrating the equations of motion (*First Annual Report National Advisory Committee of Aeronautics Washington, 1915 pp. 52-75*). It has the disadvantage that the motion can be followed only for a very brief time and it is inapplicable for obtaining significant results in Problem 3. The author has therefore in this case to treat only the forced oscillation, assuming that the natural oscillations due to the initial disturbances have died out.

ADVISORY COMMITTEE FOR AERONAUTICS APPENDIX TO REPORT NO. 19 (1916)

THEORY OF A STREAM LINE PAST A CURVED WING

By Sir G. Greenhill. London, H.M. Stationery Office 1916. 34 pages, 81 figures.

The two-dimensional motion of a perfect liquid past a long plane rectangle with its edge normal to the stream and its surface at any angle to the undisturbed stream was solved with the aid of the theory of functions of a complex variable by Lord Rayleigh. Various more complicated prismatic barriers have also been treated in original articles by numerous scientists, and may be found in the standard treatises on hydromechanics, in the Report to which this is an appendix, or in Greenhill's book on "The Dynamics of Flight." The problem is one in discontinuous motion—there being a region of deadwater—and includes the theory of jets or vena contracta.

It would be of interest and importance for theoretical hydraulics and aeronautics to have a method by which the effect of a stream upon a cylindrical surface such as a cambered airplane wing could be calculated. The cylindrical surface would naturally be regarded as the limiting form of a prismatic surface when the number of sides increased indefinitely. To find the flow past a given cambered surface is not easy. The simpler method is to fix different forms of flow which appear likely and calculate the shape of the cambered surface which would give rise to them. Greenhill carries out the work for a large number of cases. The analysis is not sufficiently elementary to be followed by those who have not had a considerable training in mathematics and hydromechanics. The numerous figures however will tell a good deal to the engineer.

RADIODYNAMICS

By B. F. Miessner. (D. Van Nostrand & Co.) Price $2.00 net. Pp. 206. 112 Illustrations.

This book gives a comprehensive review of the art of the wireless control of torpedoes up-to-date.

The first part of the book is given up to the discussion of the historical development of various forms of wireless communication including electromagnetic, electrostatic and inductive phenomena. The latter part deals with future possibilities and the present control of torpedoes by means of acoustic, hertzian, infra-red and ultra violet rays.

The author has aimed especially at a treatment of his subject that would be intelligible and interesting to the general reader without sacrificing the technical exactitude which makes scientific work of value to the trained engineer.

This work should be interesting to students of aeronautics as control of torpedoes both submarine and aerial for airplanes is not far removed.

THE AEROPLANE SPEAKS

By Captain H. Barber. (London: McBride, Nast & Co. Ltd.) Price $1.90. Pages 144. 36 pages types of airplanes. 87 sketches and diagrams.

We feel certain that this is one of the most fascinating books dealing with aeronautics ever published. In the prologue the Elementary Principles air their grievances.

Miss Efficiency, the athletes Lift and Thrust, the unsteady Stagger and other flight folk argue and settle their differences before a friendly blackboard. Nothing could be so illuminating of the fundamental principles of flight as this fanciful discussion.

The prologue over, the main definitions are given in accurate and easy form with excellent sketches.

In giving the essentials for maximum climb, the author states that the propeller thrust should always be horizontal and the angle of the wings to the propeller axis in consequence very large. Unless this is taken to mean that the propeller thrust should always be in the line of flight, this recommendation is highly controversial. If the machine is climbing on a steep slope, it would be inefficient to have the propeller thrust horizontal and not on the flight path. The author states that it is not advisable for the propeller to act as a helicopter, but under such circumstances it would actually act as a helicopter acting downwards.

The chapter on Stability and Control is most clear and accurate.

Under the title rigging, the author deals with the most important points in construction. The proper adjustment of struts and wires, the boring of holes in wood, and the correct methods of cable and wire connections are dealt with by a man of evidently great experience.

The book should be most useful to pilots training for military service and to conscientious instructors who wish to give their pupils something more than a rule of thumb knowledge of their machines.

Aerial Mail Route Contemplated

The first aerial mail route within the continental limits of the United States will be established between San Diego and San Francisco and then extended until the system reaches nearly every important city in the country, according to an announcement made at San Diego, Calif., by an aviation officer of the United States Flying Corps.

The Handley Page Giant Biplane

Some more photographs are available of this interesting machine which, according to the designer, holds a world's

FRONT VIEW

record for passenger carrying. Mr. Handley Page states that in this machine Clifford B. Prodger, an American pilot, took up twenty passengers to a height of 7,180 feet.

From the three views of the machine on the ground, it is possible to obtain a very clear idea of the beautiful system of engine support. Special efforts have been made at streamlining the nacelle in the struts over the body. It is interesting to note how in large machines a more bridge-like type of construction creeps in—the two inclined struts being strengthened by a horizontal tie rod. The shock absorber is of the oil pneumatic type. It would be interesting to know exactly how it is adapted to the wheels. From the photograph of the machine in flight, one would judge that the back struts are either hinged at the top or slide through the lower plane.

The enormous body provides a total enclosed space for the passengers. In a previous issue of AVIATION AND AERONAUTICAL ENGINEERING it was stated that Mr. Handley Page's paper tried to prove that there is no such thing as limitation of size in the airplane. The paper, which is now being very widely discussed, simply demonstrated the possibility of important saving in structural weight with large size machines. The following is a brief extract of the paper:

Consideration of the subject of airplane size raises the question as to whether or not there is a limit to their size, and therefore whether further progress in construction will be limited to improvements in present types or extended to the development of much larger types. No advantage would follow from an increase in size if it is accompanied by a disproportionate increase in weight which would more than offset constructional advantages, or if the large airplane should have aerodynamical disadvantages.

THREE-QUARTERS FRONT VIEW

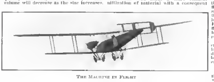
In order to have a quick means of comparison of planes of various sections and loading, a system of plotting has been adopted differing from the customary method, so that the performance of a machine can be predicted directly from wind tunnel tests of the L and L/D of the planes and the body resistance. This new method takes into account the effect of altered loading and varying density of the air.

It consists in plotting $\sqrt{\frac{1}{K_y}}$ and $\frac{K_x}{K_y}\sqrt{\frac{1}{K_y}}$ where K_y and K_x are the absolute values of the lift and drift coefficients. Then in the resulting curve, if we multiply the values of $\sqrt{\frac{1}{K_y}}$ by a factor "a" and $\frac{K_x}{K_y}\sqrt{\frac{1}{K_y}}$ by a factor "b," we shall have actual velocities and corresponding horsepower required for the planes. The factor "a" $= \sqrt{\frac{W}{A} \times \frac{g}{r}}$ and "b" $= \frac{W}{550}\sqrt{\frac{W}{A} \times \frac{g}{r}}$ where W = total weight of the airplane, $\frac{W}{A}$ = wing loading, and $\frac{r}{g}$ = absolute density of the air.

These curves then are actually curves of the horsepower required per pound weight of the airplane for a given loading. Provided the same weight per horsepower is used and the same plane section, one curve represents all machines. If we similarly plot a curve of $\sqrt{\frac{1}{K_y}}$ and $\frac{K_{xb}}{K_y}\sqrt{\frac{1}{K_y} \times \frac{S}{A}}$, where K_{xb} is the absolute body resistance coefficient and $\frac{A}{S}$ the ratio of body area to plane area, we may by a combination of these curves determine at once the total horsepower

THREE-QUARTERS REAR VIEW

required for the machine. For larger bodies, the resistance will increase as the square of a linear dimension while the volume will increase as the cube. Consequently the body resistance per unit volume will decrease as the size increases.



THE MACHINE IN FLIGHT

This decrease in resistance will have a cumulative effect in decreasing the weight of the remainder of the machine.

Local Strength Necessary

There is a structural disadvantage in small machines in that as the size is reduced, the members of the structure cannot be reduced correspondingly below a certain limit for the reason that certain minimum thicknesses are necessary for adequate local strength. A large machine can then make a more efficient utilization of material with a consequent reduction of relative weight of planes and body. Local strength also is the main consideration in the construction of such parts as the tail skid and ribs, and with increase in size, this local strength need not be increased, with a consequent further economy in weight.

From the foregoing considerations of aerodynamical and structural qualities, it may be concluded that for the same total weight per horsepower the large machine will show better performance.

Finally from the pilot's standpoint, though there has been less experience in flying larger machines, it may be safely said that by proper balancing of controlling surfaces the large machine can be built to fly as easily as the small one. Furthermore, there will be less work in flying the large machine since it will not be affected by wind gusts to the same extent as the small one.

From the point of view of load to be carried, there is no competition between large and small machines. To carry a desired load the size of the machine must be increased until the useful load is large enough.

Discussion

Following the delivery of the lecture there was a discussion in the course of which it was objected that structural weight must necessarily increase faster than the size of the airplane if not actually as the cube of the dimensions still at such a rate that a limiting size will be reached. It was proposed in favor of the large machine that since it cannot be thrown about by the pilot it does not require so great a factor of safety as the small machine.

The National Advisory Committee for Aeronautics

As to the National Advisory Committee for Aeronautics, and its functions, there seems to be a lack of knowledge on the part of the public at large and even those directly interested in the aeronautical industry. The National Advisory Committee for Aeronautics was established by Act of Congress, approved March 3, 1915. In a large measure it was in response to a nation wide interest in aeronautics, aroused, no doubt, by the extensive use of aircraft in the war in Europe.

The twelve members of the committee were appointed by the President, two each from the War and Navy Departments, a representative each of the Smithsonian Institution, the Weather Bureau and the Bureau of Standards, and five additional scientists acquainted with the needs of aeronautical science, either civil or military, or skilled in aeronautical engineering or its allied sciences. The members of the committee, as such, serve without compensation.

The creation of the National Advisory Committee for Aeronautics was the first important movement inaugurated for effective cooperation between the Government departments interested in aeronautics, and the industrial interests of the nation, especially those engaged directly in the manufacture of aircraft. The committee completely represents all interested departments of the United States Government and in addition, has the authority to officially coordinate their efforts and to cooperate with the manufacturers and designers of aircraft.

Duties of the Committee

In general, the duties of the committee as prescribed by law, are to supervise and direct the scientific study of the problems of flight, with a view to their practical solution and to determine the problems which should be experimentally attacked and to discuss their solution and their application to practical questions.

The committee was organized on April 23, 1915, with temporary headquarters in the State, War and Navy Building. The rules and regulations which were adopted by the committee at this meeting and later approved by the President, provide for the annual election of a chairman and a secretary, and also authorize an executive committee consisting of seven members of the Advisory Committee. To the executive committee full authority has been delegated to control the administration of the affairs of the committee and to supervise all arrangements for research and experiment undertaken or promoted by the committee. The committee, however, will not expend public money for the development of inventions or experimenting with inventions for the benefit of individuals or manufacturers.

The full committee meets twice a year—in April and October. The Executive Committee holds regular meetings monthly, and special meetings when necessary.

Subcommittees

To facilitate the work of the committee, the following subcommittees have been established:

Aerial Mail Service, Brigadier General George O. Squier, U. S. A., Chairman.
Aero Torpedoes, Lieut. J. H. Towers, U. S. N., Chairman.
Aircraft Communications, Dr. Michael I. Pupin, Chairman.
Airplane Mapping Committee, Brigadier General George O. Squier, U. S. A., Chairman.
Bibliography of Aeronautics, Prof. Charles F. Marvin, Chairman.
Buildings, Laboratories and Equipment, Dr. Joseph S. Ames, Chairman.
Design, Construction and Navigation of Aircraft, Brigadier General George O. Squier, U. S. A., Chairman.
Governmental Relations, Dr. Charles D. Walcott, Chairman.
Nomenclature for Aeronautics, Dr. Joseph S. Ames, Chairman.
Patents, Dr. Charles D. Walcott, Chairman.
Physics of the Air, Prof. Charles F. Marvin, Chairman.
Power Plants, Dr. S. W. Stratton, Chairman.
Relation of the Atmosphere to Aeronautics, Prof. Charles F. Marvin, Chairman.
Standardization and Investigation of Materials, Dr. S. W. Stratton, Chairman.
Foreign Representatives, Dr. Charles D. Walcott, Chairman.

First Annual Report

The First Annual Report of the Committee reviews the work for the first six months of the committee's existence and contains technical reports as follows:

Behavior of Airplanes in Gusts. By the Massachusetts Institute of Technology.
Investigation of Pitot Tubes. By the United States Bureau of Standards.
Investigation of Aviator Wires and Cables, their Fastenings and Terminal Connections. By John A. Roebling's Sons Company.
Preliminary Report on the Problem of the Atmosphere in Relation to Aeronautics. By Prof. Charles F. Marvin.
Relative Worth of Improvements on Fabrics. By the Goodyear Tire & Rubber Company.
Investigation of Balloon and Airplane Fabrics. By the United States Rubber Company.
Thermodynamic Efficiency of Present Types of Internal Combustion Engines for Aircraft. By Prof. Charles E. Lucke.

Second Annual Report

The second Annual Report of the committee contains reports on the following subjects:

General Specifications Covering Requirements of Aeronautic Instruments.
Nomenclature for Aeronautics.
Mufflers for Aeronautic Engines.
Gasoline Carburetor Design.
Experimental Researches on the Resistance of Air.

The committee has investigated the facilities available in various colleges, technical and engineering institutions and among manufacturers and aeronautical societies, for carrying on special investigations.

Future Work Outlined

At the present time the committee is proceeding with the establishment of a field experimental station near Hampton, Virginia, for the scientific study of aeronautical problems.

The committee expects to have a testing laboratory, wind tunnel, and machine shop, and specifications for the necessary buildings are being prepared. The operations of the committee will be in conjunction with the Army and Navy.

An investigation of air propellers, under the direction of the Chairman, Dr. Durand, is being conducted at the Leland Stanford Jr. University and a special wind tunnel has been installed there in connection with this work. It is expected that the result of this investigation will appear in the Third Annual Report of the committee.

Military Airplane Photography

By Arthur Brock, Jr.

Even before the Civil War, attempts were made to take photographs from captive balloons. The trials were the direct result of the work of Captain de Laussedat of the French Engineer Corps, who in 1850 suggested the use of photography for surveying. The art of photography, however, had not sufficiently advanced at this date. Nevertheless, photographic surveying soon became a success even with the wet-plate process, so that after the development of the dry plate process, various methods were adopted by a number of governments. The results obtained from photographs were such in the details and correct location of objects, that from the earliest military use of airplanes, the importance of photography was understood.

It is not possible in a short article to enter into discussion of the development of military cameras but simply to state what are the principal objects, results, and how they have been obtained. The primary object of airplane photography is to obtain a complete and perfect record of that part of the terrain seen from an airplane; the secondary object is to obtain a record in large enough scale to permit the recognition of most of the points of importance; while the third is to permit the placing of the various objects as seen on the photographs in their true location on the map. Practically coincident with the development of airplane photography was the use of dummy guns, tree branches, paint, etc., to give false information. One result of such photographs has been to change entirely the manner of placing field guns, since now a well marked gun pit does not necessarily denote the presence of a gun, as there may be found three or more well marked gun-pits to each gun in actual use.

Daily Photographic Flights

The military application of the first object has resulted in the terrain being photographed daily, in some cases twice a day to show the relative positions of the trenches and placements, as the differences in position are important evidence of the moves of the enemy, while at the same time conveying very valuable information as to the numbers of troops, gun positions, and intrenchments. In fact, in the European War it has been found advantageous to obtain records from day to day of the holes made by high explosive shells which may be available for cover in carrying out attacks. This led to photographs on a scale sufficiently large to permit of the closest possible identification in the negative, or print.

It was not a simple matter from a photographic viewpoint, to take such large pictures, as the use of longer focus lenses in many instances showed the effects of vibration, unless very fast shutter speeds were used to reduce the circle of confusion. Moreover, the increasing elevations at which photographs were taken did not improve matters any, as it led to the use of still longer focal lengths. This difficulty has now in a large part been overcome by various shock absorbing attachments, so that in most cases today, the shutter speeds are limited more by the speed of the airplane in relation to the ground than by the airplane vibrations, as set up by air currents or the motor. Until quite recently the average scale of military photographs was about 1/5000 actual size. Since this is the scale of a true horizontal photograph with a 12 inch lens at 5000 feet elevation, it is obvious that with the increased trajectory of anti-aircraft guns in some instances lenses of extreme lengths were used.

Not all military photographs are taken on an approximate scale of 1/5000 actual size, however, as in trench warfare, wherever possible it is preferable to use scales somewhat larger, in many instances 1/1500 actual size. With scales as large as the last mentioned, it is very difficult to conceal any object by artificial means, the discovery of which is the second feature of photographic reconnaissance.

The last object of military photography is to place all enemy positions in their true position on the map and to permit the calculation of ranges to points otherwise of unknown distance. In practice, this has resulted in the location and destruction of field guns some few hours after a photographic reconnaissance flight. It is evident that the features of an airplane camera tending to simplify and add to the information contained in the maps will largely govern the design. The principal difficulty encountered in mapping positions from airplane photographs has resulted in various methods of attachment to the body designed to obtain approximate or absolutely true horizontal projections of the earth's surface. Since, if the plane of the photographic negative is truly horizontal the photograph is a true map. There have been few attempts made to realize all the possibilities of this method as it adds considerably to the complication of the suspension and the method of operating the camera. Consequently very few military airplane cameras are used which are not designed to obtain approximately horizontal projections. Incidentally the error in location equals the sine of the angle of the negative to the true horizontal position.

Apart from the desideratum of mapping, the reduction in the scale is a serious matter—as if the axis of the lens is at an angle of 45° to the vertical, at least one half of the picture is more or less indistinct owing to the diminishing scale. As previously mentioned the focal length of the lens of a military airplane camera is seldom under 12 inches (the standard for one country is 10½ inches), for the reason that the definition of the original negative cannot be improved by enlargement.

THE CAMP AT COLUMBUS, N. M., PHOTOGRAPHED WITH A BROCK CAMERA

On the other hand, most negatives are enlarged, as it simplifies the work of the staff officers, and positives are made within twenty-four hours, of many photographic negatives which are projected for the benefit of the assembled staff officers of the division. But this is done more especially to reduce the quantity of photographic prints needed in trench warfare.

Anastigmat Lenses

In general, none but the very best types of anastigmat lenses are used for airplane cameras. First, because of their large openings and second because of their better correction. Besides the standard lens of about 1 foot focus, for certain other classes of work, very long focal lengths are used which can in some instances be advantageously replaced by a tele-photo combination.

Rapid rectilinear lenses are also used. The correction of this type of lens does not bar their use in this work since a comparatively narrow angle of view is used. Furthermore, it has not been found possible to make certain glasses necessary for the manufacture of anastigmat lenses in large enough blocks to obtain the advantages of the larger openings, since when lenses of 36 inch focal length are used, it is practically impossible to make the anastigmat type larger than F 7.7, whereas it is perfectly possible to make the rapid rectilinear type in F-6.

For the shorter focus or usual type of lens, the effective opening is seldom less than F-4.5. This has been found the largest practical size for sharp definition with

most of the commonly used systems of lens corrections, although under stress of the European War the manufacturers of one country have produced satisfactory lenses of F-3.5 opening and about 1 foot focal length, and F-4 is becoming common. The use of these very large openings is made possible by reason of the fact that the most commonly used negative sizes do not exceed 4x5 inches (1 except the long focus cameras, as their plate sizes run up to 17x21 inches.) This would not be possible with, say, 8x10 inch plates, as the lens would have to be stopped down to obtain sharp enough definition for airplane photographs.

It would not be necessary to use such large lens openings were it not for the fact that whenever the weather permits photography, it is preferable for other reasons to make the photographic flights soon after sunrise or just before sunset. These conditions are specially difficult in Europe owing to the northern latitudes, and the prevailing climatic conditions in the winter.

The standard sizes of the negatives of military aeronautical cameras have been adopted partly as a result of the type of lenses used, but more to conform to the standard sizes in use in the country and whether films or dry plates were used.

Another factor taken into consideration has been the necessity of making a very large number of contact prints and negatives because usually three prints are required from each negative and one or two enlargements. Under these circumstances, it is much easier to make a large number of small prints, than a lesser quantity of large prints. Assuming that the usual scale of reduction in the contact print is 1/5000 actual size for the smaller or commonly used type of camera, and that the common size of the negative is 4x5 inches, it is evident that it is necessary to have a plate of more than 12x16 inches to cover the same area on a scale of 1/1500 actual size unless a great many more negatives be exposed.

In Europe the increasing use of long focus lenses has resulted in a very considerable increase in the use of the large plates. In part, however, this has been due to the general use of the hand-operated magazine plate camera which is not adapted to larger than 5x7 inches, without a corresponding reduction of the number of exposures. A good example is a standard military camera of magazine type, containing eighteen 4x5 inch glass plates, with a 10½ inch lens. The same army uses a single exposure 17x21 inch plate camera with their long focus lenses and the plate holder must be changed for each exposure, as the magazine construction is too bulky.

Weight of Airplane Cameras

The weight of the military airplane camera has now to a certain extent become a minor consideration. One long focus type used by one European army is said to weigh 180 pounds. If aeronautical photography is to be done beyond the range of anti aircraft guns in the near future, it is quite possible that special airplanes will have to be designed to be able to obtain the elevation, on account of the dead load. At the present time the lifting capacity of the reconnaissance military airplanes does not permit photographing at elevations beyond the range of the anti aircraft guns, although hits are rare both on the low photographic flights and the high photographic flights, yet the improvements in anti aircraft gun sights and shells, may yet cause photographic flights under European conditions to be made at 18 000 to 20 000 feet elevation.

One of the major difficulties experienced in Europe in airplane photography has been that of proper negative emulsions. Wherever the terrain was of a non actinic color such as green or yellow, or shades of these colors, and wherever the principal points of interest were shades of these colors, it has been found preferable to use orthochromatic emulsions and ray filters. Orthochromatic emulsions are, however, somewhat slower than the standard fast negative emulsions, and with the loss of light due to the use of the ray filter, shutter speeds become a serious problem, with the result that for a large part of the photographic work it has been found impossible to use the ray filters. Ray filters are practically indispensable near the ocean however, as they lift the blue haze which is commonly found.

The growth of airplane photography in Europe has been largely due to trench warfare. Furthermore the accuracy and the scales of the military maps have to a large extent simplified the work, thereby permitting a sufficiently complete set of data to be obtained from a number of individual photographs, taken approximately horizontal.

Similar methods as applied to the work of the Aviation Section of the Signal Corps would not be, by any means, as satisfactory owing to the less valuable military information contained in the maps. The photographic work of the United States Army will therefore be more in the nature of actually constructing military maps.

The importance of this has been fully understood by the officers of the Aviation Section of the Signal Corps, and with their assistance and cooperation it has been possible to design and perfect a number of photographic instruments to accomplish the following results:

First. To make any photographic series into a plan view map.

Second. To show relative elevations of the ground positions when desired in any photographic flight.

Third. To print any photographic series into a photographic map and

Fourth. This processes are as nearly mechanical as it is possible to make them.

The importance of this work will be realized when it is borne in mind that comparatively few areas in the United States are mapped on a scale as large as three inches to the mile. Even these large scale maps are not perfect from a military viewpoint, as they are not corrected often enough to contain all the information desired, making it necessary to insert corrections in the event of war. Furthermore, the most likely places where a campaign would be conducted by the United States Army are in the semi tropical parts of the country or possessions where large scale maps are conspicuous by their absence, practically necessitating the Engineer Corps, and the Aviation Section of the Signal Corps making maps during the campaign.

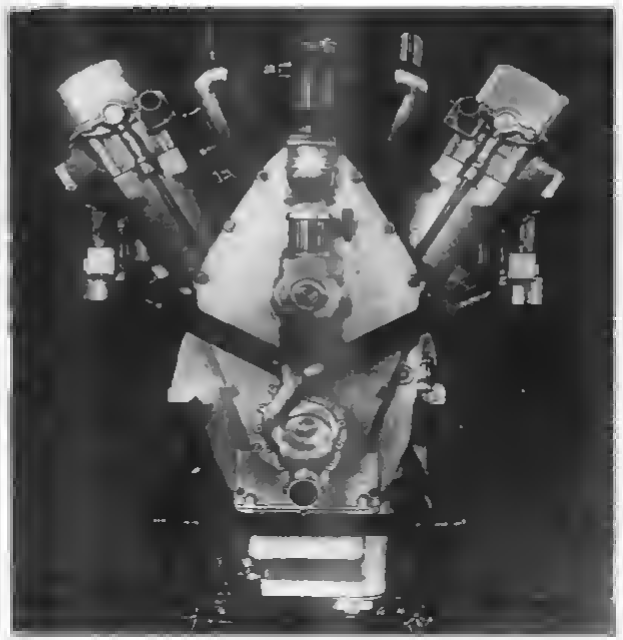
The accuracy with which airplane surveys can be made will, naturally depend to a large extent on the human element, but if proper allowance is made for the motion of the camera during exposure (growth) it will probably be possible in many instances to obtain a high degree of accuracy. It is not to be supposed that sufficient information is obtained for building a railroad line, but enough information will be secured for selecting the route through a comparatively unknown country.

The scale upon which the United States Army photographs will ordinarily be made ranges from 1/2500 to 1/5000 actual size. Provisions have been made however, for altering any camera to operate on a larger scale when found necessary. Although the standard United States cameras are designed to operate with long focus lenses it is unlikely that very large size plates will be used. One reason is that the climatic conditions of the southern half of the country would make quantity development very difficult; and another reason, is that, with the present methods of operating the cameras it is preferable to make a large number of small photographs.

A very distinct advantage is obtained from the 4x5 size, in that the work of producing hundreds of prints per day per squadron as is the case in war conditions, is minimized. In Europe it has been found advantageous to furnish photographs of their section to the regimental units, the brigade commanders, and the corp commanders. This necessitates producing three or four prints and one or two enlargements of each negative which has been made that day. When a single flight may result in more than 200 negatives, the quantity of work to be done can be appreciated, and in the light of the lessons learned in the present great war, it is reasonable to expect that our country will employ similar improved methods.

The above photograph shows the aviation camera developed by the Folmer & Schwing division of the Eastman Kodak Co. The camera is 22 x 8 x 5 in., weighs 10 lb., and is fitted with a special telestigmatic lens of 14-in. focus, set so that a 24 in. focal result is secured. The shutter is released by pulling the trigger, and the range of exposure is from time to 1/1000 of a second. Negatives 4 x 5 in. are made.

Knox Engine Passes U. S. Navy Test



On March 13, 14 and 15 the Knox 300 hp. engine successfully completed the tests required and conducted by the Department of Inspection of Engineering Materials of the United States Navy. The tests consisted of:

First—Making a run for determining the points of a horse power vs. revolutions curve.

Second—A run of six hours at rated load and rated speed.

Third—Engine was entirely disassembled, thoroughly inspected, measured up and reassembled.

Fourth—A run of an hour was made after reassembling.

The tests were conducted in the research laboratory of the Knox Motors Company at Springfield, Mass., which is equipped with a Sprague electric dynamometer for measuring the output of the engine. It was not possible at the time of installation of this dynamometer to obtain one unit large enough for the purpose, therefore, two units were used coupled in tandem, each unit having an arm the same length so that direct scale readings for torque could be made and added together without further computations.

The gasoline used had a specific gravity of 743 or Baumé 585, and a calorific value of 18,900 B.t.u. per lb. and was measured in calibrated tanks. The lubricating oil used was Oilzum fed by a gear pump with a capacity of 12 gals. per minute at 70 lb. pressure.

The cooling water was contained in a large tank into which the entrance of fresh water could be regulated so as to keep the water entering the engine at a pre-determined temperature. In the six hour run 26½ per cent of the heat units were absorbed by the water. This is about 60 per cent of the amount generally used in automobile engines and thus allows of a much smaller radiator per horsepower.

The engine is a 12 cylinder of 4½ in bore by 7 in stroke rated at 300 hp at 1800 r.p.m., geared down to 1060 r.p.m. of propeller and fully equipped with electric starting total weight being 1430 lb. Besides the starting and lighting system it carries a two-cycle air pump for furnishing pressure to the gasoline system and also a stub shaft is brought out for driving the generator of a wireless apparatus.

The equipment consists of two Zenith 24a duplex carburetors, Delco battery type ignition, Rajah metric porcelain sperb plugs, Bijur starting motor and generator. The current for ignition is taken from the battery at starting and from the generator when running.

Forty seven per cent of the weight of the engine is a special aluminum alloy. The crankshaft is of chrome nickel steel carefully treated for great toughness. When each end is held on supports the center may be deflected over two inches without a permanent set. Other parts are made of high grade alloy steels, treated in the Knox plant to give the qualities required by the use of the piece. Great pains were taken to so design the engine that all parts were made in one piece as far as possible to eliminate the danger of loosening joints. The timing spiral gears are integral with their shafts. The propeller gears are splined to the shafts with integral splines. Even the propeller shaft has no key in the taper, the hub having integral dogs which mesh with integral jaws on the shaft. The engine has a compression ratio of approximately 4.2 to 1 giving a cold compression at 120 r.p.m. of 75 lb.

The first test consisted in making a run with wide open throttle to obtain the points for plotting a revolution vs. horsepower curve. The speed readings were taken at three different points, viz., the electric tachometer on the dynamometer switchboard, a revolution counter on the propeller shaft, and a second revolution counter on the motor half time shaft. The torque was measured on the dynamometer scale balance beams so that at each point the engine was run about five minutes including the greatest speed (2400 r.p.m.), at which speed the pistons have an average speed of 2800 ft. per minute. At the average speed of the test the piston speed was over 2100 ft. per minute, yet when the engine was dis-assembled for inspection after the six hour run, no wear could be found in the pistons or the wrist pin bearings.

The readings taken for this revolution vs. horsepower curve were:

Engine r.p.m.	Propeller r.p.m.	h.p.	Torque ft. lbs.
1217	730	225	1085
1350	810	255.5	1055
1605	960	308	1215
1797	1078	322	1505
2030	1224	347	1485
2217	1340	353	1375
2390	1428	340.5	1265

The readings taken during the six hour run were as follows:

Time Hrs. Min.	Engine r.p.m.	h.p.	Oil pressure	Water inlet	Temperature outlet
00	1807	297	75	105	137
15	1820	309.5	70	102	136
30	1824	310	60	104	138
45	1815	309	60	104	138
1 00	1807	307	60	110	140
1 15	1794	305	60	108	140
1 30	1810	307.8	60	106	140
1 45	1831	311.5	60	88	129
2 00	1780	303.6	62	100	136
2 15	1793	305	63	103	137
2 30	1789	304	64	64	124
2 45	1809	307.5	62	91	133
3 00	1795	305	61	98	137
3 15	1840	312.6	60	66	134
3 30	1811	308	61	92	134
3 45	1864	317	62	100	134
4 00	1816	308.5	61	100	134
4 15	1814	308.5	62	102	136
4 30	1826	237	65	100	136
4 45	1810	287	65	100	136
5 00	1800	306.8	61	103	134
5 15	1808	304.8	60	101	135
5 30	1845	307	at	98	134
5 45	1838	304	60	98	134
6 00	1802	310	60	94	134
Average	1835	304.28	62.66	99.92	135.48

Shortly after four hours and fifteen minutes had elapsed the valves between the calibrated gasoline tanks and the carburetors were accidentally closed by one of the employes who mistook these for the valves used in filling the calibrated tanks. The cause of the stop was immediately located the engine restarted and the readings made at four hours and one-half at which time it was noted that the resistance grids of the dynamometer set had become so hot that their resistance effect was lessened and there was not enough load to hold 300 h.p. at the rated speed. As horsepower is a combination of speed and torque when the torque decreases it is necessary to increase the speed therefore it was decided to increase the engine speed to bring the horsepower over its rated three hundred.

During this six hour run 22.45 per cent of the heat units were converted into work, 26.5 per cent was used in the cooling water and 51.05 per cent used in radiation, friction, exhaust, etc.

After this run the engine was disassembled, various parts measured for wear and careful search made for defective parts. One exhaust valve which showed slight pitting in the seat was the only part replaced. No other valves were reground, no bearings readjusted and no other parts altered or adjusted in the slightest degree. The bearings, both main and connecting rod were accurately measured and no wear could be detected. The wrist pins, cylinders and pistons were also carefully measured and no wear could be detected.

The engine was then reassembled and run for one hour during which the following readings were taken:

Time Hrs Min	Engine r.p.m.	h.p.	Oil pressure	Water—Inlet	Water—Outlet
0	1811	308	68	94	134
15	1835	312	90	99	132
30	1848	314	90	103	135
45	1801	313	57	98	134
1 00	1877	317	88	102	134
Average	1828	312.8	60.4	99.2	134

Army Plan for Training Aviators

The National Advisory Committee for Aeronautics has prepared a plan for the training of military aviators which has been approved by General Squier Chief Signal Officer of the Army and has already been put into effect. Officers of six educational institutions met in Washington and Professor William F. Durand of the National Advisory Committee for Aeronautics and Professor Hiram Bingham Yale University outlined a plan whereby the colleges could cooperate with the Signal Corps in giving preliminary training to applicants for duty in the Aviation Section of the Army. The Massachusetts Institute of Technology, Cornell University, Ohio State University, University of Illinois, University of Texas and the University of California were represented in the conference. Each college was requested to send three members of its faculty to Toronto to observe the method of training student aviators at Borden Field and the University of Toronto. The following representatives went to Toronto and spent several most instructive days: M. I. T., Professor R. D. Ward; Alexander Klemin, Dean Abner Fales. Cornell University, Professors F. Bedell, F. O. Ellenwood, O. M. Leland; Ohio State University Professor P. T. McKuler; University of Illinois Professors R. N. Fales, F. H. Newall, George Arnold; University of Texas Professors J. M. Bryant, S. T. Brown, T. S. Victor; University of California, Professors B. Woods, B. F. Raber and L. I. Jones.

Course of Instruction

The Royal Flying Corps Cadet Course, which is the preliminary instruction given to all candidates for commissions was thoroughly explained by the officers in charge. A modified form of this course will be given at the six institutions commencing as soon after May 15th as is practicable. The course will be modified to suit American conditions. The selection of the six colleges was influenced to some extent by the fact that each of them have a regular army officer in charge giving military instructions. It is regarded as essential that all candidates for commissions should have military training and therefore the course of military discipline and drill without arms will occupy two or three hours daily. Instruction will be given in troop formation and the organization of flying corps will be thoroughly studied. Approved courses in astrology and meteorology, theory of flight, internal combustion engine principles, signalling, wireless and photography have been prepared. Students will be required to put airplanes together and dismantle them. This course of rigging will be supplemented by a study of aeronautical instruments, compass work, map reading and artillery observation and signaling. The various types of machine guns, bombs and bomb sights will be explained and, if possible, practical instruction given in their operation. At the end of the course an examination will be held and those who successfully pass will be detailed to different training schools.

Types of Students Desired

The types of students desired for these courses can be divided into four classes. First those who have had engineering and military training and who have had experience as pilots. Second, those without aviation experience who have had engineering and military training. Third, those with engineering training. Fourth, specially qualified applicants who have not had any of the above experience. One hundred students are to be taken care of by each school, making six hundred in all. If this plan of giving the Cadet Course is successful, Prof. Bingham, who has been appointed special assistant to General Squier for this work, will undoubtedly extend the work to other institutions.

The second period of training will be given at the schools which are at present organized in Mineola, Memphis and San Diego. Four or five other schools will be established in the near future, probably at Detroit, Dayton near Chicago, San Antonio and at some point near St. Louis. Students from the University of California will report to San Diego, students from the University of Illinois will report to Chicago, from the University of Texas to San Antonio, from the University of Ohio to Dayton, from Cornell to Detroit and from M. I. T. to Mineola. It is believed that four or six weeks' training at the colleges will prepare students for their work at the primary training camps and will save much time.

It is estimated that to complete the flying course will require four to five months. The estimated capacity of the schools at the outset will be: Mineola 100, Detroit 50, Dayton 50, Memphis 50, San Diego 70, Chicago, 50. The number to be trained at San Antonio has not been determined.

Each training camp is organized on the basis of one squadron with thirty-six machines. This capacity is to be increased as rapidly as possible. No site for a training camp is being considered with less than 640 acres. This will make city property unavailable. The location of camps will probably have to be at some distance from centres of population.

The work of procuring equipment and organizing these camps has been divided into two distinct parts. The production part obtains sites, constructs buildings and supplies machines. The Aero Division of the Signal Corps organizes and trains the students from the beginning to the end. The cadets are enlisted as sergeants and corporals and will have pay and allowances of that grade. No commission will be given until the end of the primary training at one of the aviation camps.

At Fort Omaha the balloon school will be enlarged to two fighter than air squadrons and courses will be given in that branch of the service in the same way as at the airplane fields. For the information of those desiring to have detailed knowledge of the requirements the following parts of the regulations governing the organization of the Aviation Section of the Signal Corps are given:—

REGULATIONS GOVERNING THE ORGANIZATION OF THE AVIATION SECTION SIGNAL CORPS

The aeronautical personnel of the aviation section of Signal Corps will consist of officers and enlisted men of the Regular Army of reserve officers and enlisted men of the Reserve Corps of officers and enlisted men of the National Guard mustered into the service of the United States, and of civilians employed by the aviation section of the Signal Corps.

The central office will provide for four divisions of duty:

First. The provision of material to be effected by the central office through its technical departments.

Second. A system of training personnel to be decentralized but to remain under the general jurisdiction of the War Department similarly to other educational institutions and service schools of the Government.

Third. The establishment organization and equipment of aerial units at points to be designated by the War Department.

Fourth. The selection purchase and rental of sites for aeronautical purposes.

Classes of Schools

Aeronautical schools are divided into three general classes: (a) The United States Army aviation schools; (b) the United States Army balloon schools; (c) civilian schools (aviation or balloon) conducted by manufacturers or others for preliminary training.

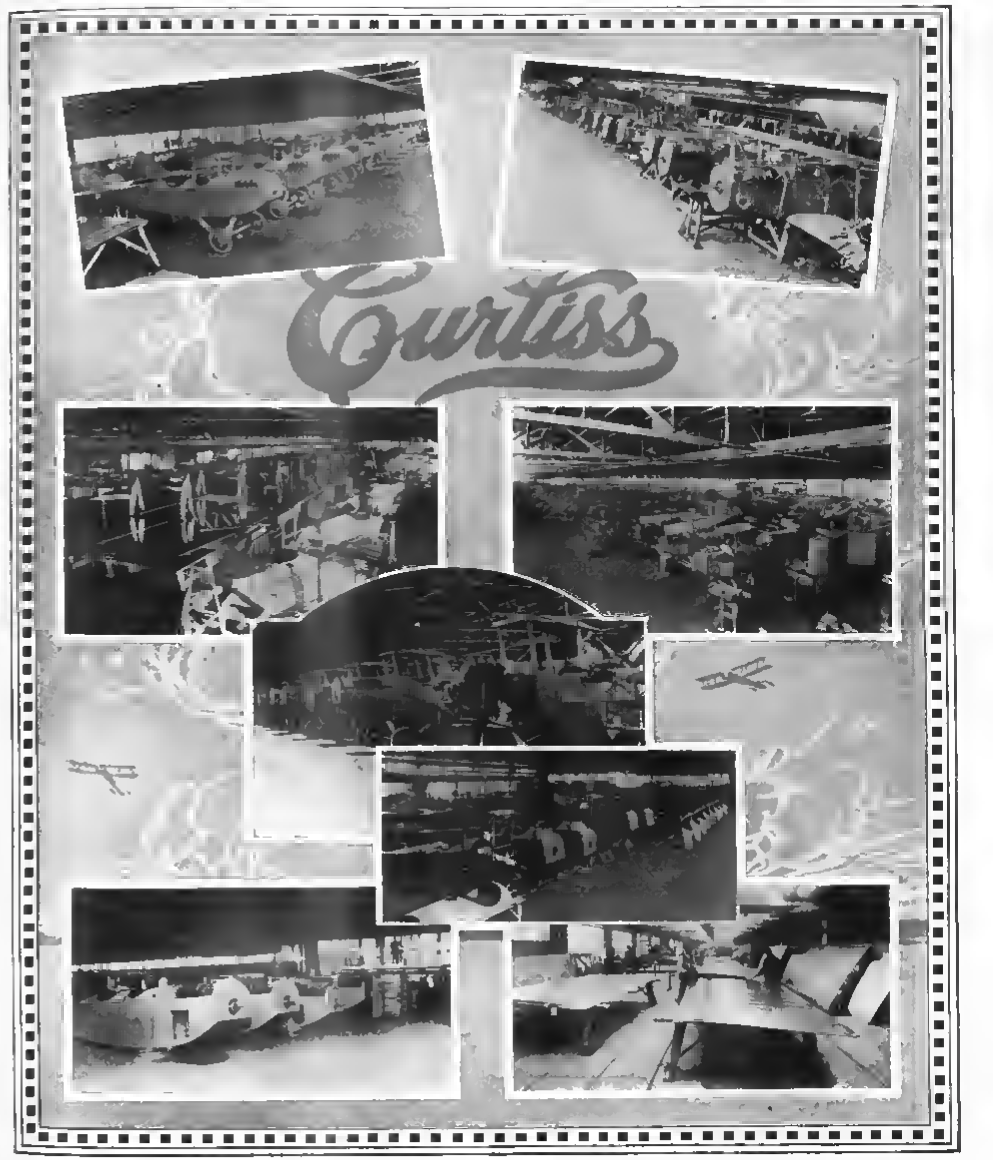
Training

The personnel and courses of instruction at United States aviation and balloon schools will be in accordance with instructions from the War Department.

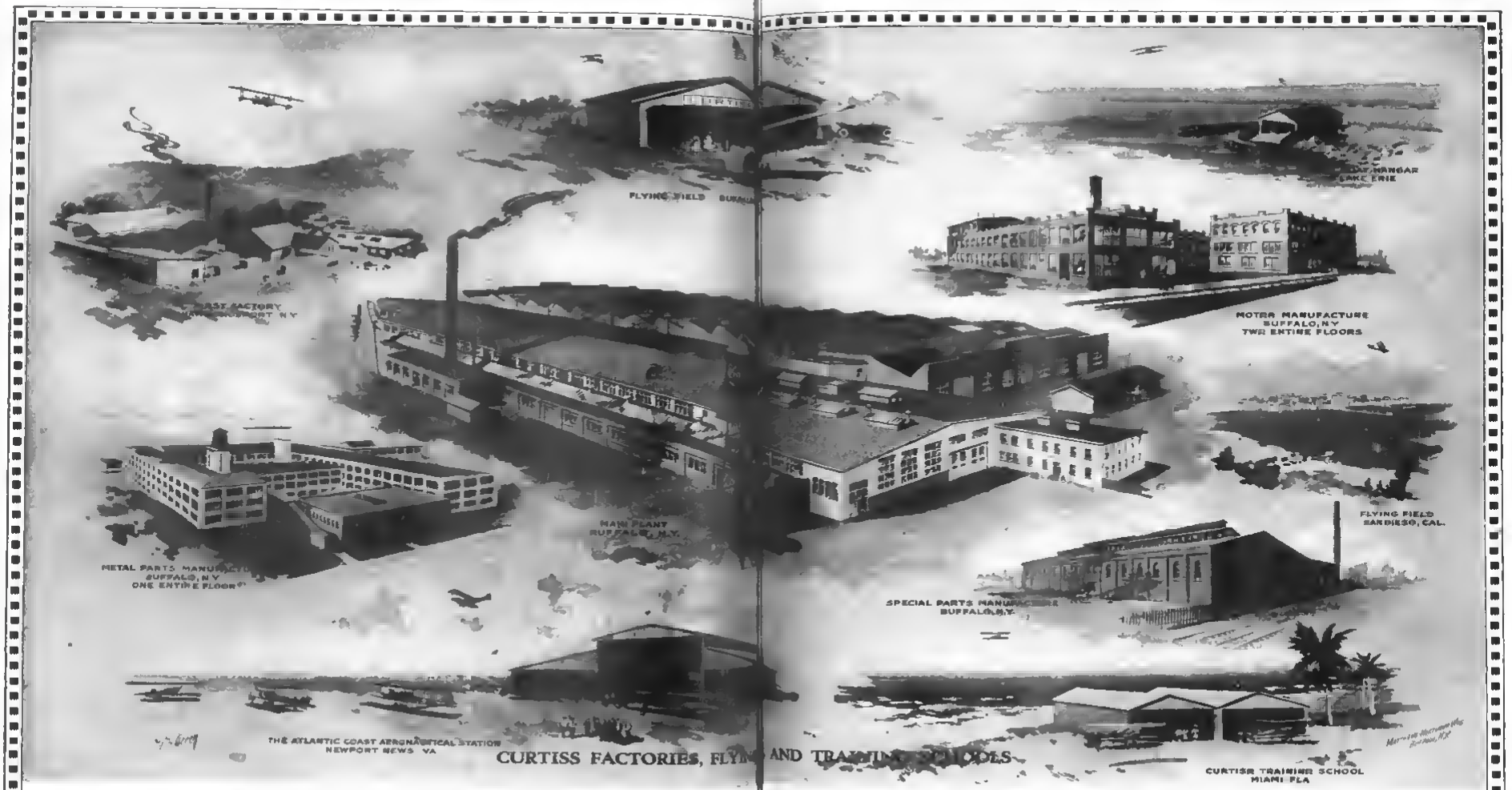
It is intended that personnel for all formations except those of the Regular Army will obtain their preliminary instruction at civilian aviation or balloon schools, after which they may finish the course at the corresponding United States Army schools and obtain their military ratings.

Military Departments

Each department will have an aeronautical officer to be designated as such on the staff of the department commander.



SUCH PHOTOGRAPHS AS THESE TELL BETTER THAN WORDS THE STORY OF CURTISS PROGRESS AND MANUFACTURING CAPABILITIES



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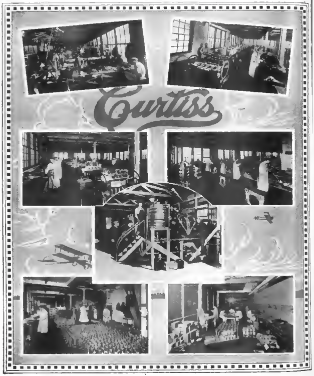
The America Trans Oceanic Co., 280 Madison Avenue, New York City, New York Agents.



THE SAME THOROUGHNESS IN WORKING TO CLOSE LIMITS AND ACCURATE STANDARDS CHARACTERIZES ALL CURTISS WORK, WHETHER IN AEROPLANE OR MOTOR CONSTRUCTION

Within the department, the aeronautical officer under the department commander will be charged with general control of all officers, enlisted men, and civilian employees of the aviation section, Signal Corps, and of all aeronautical schools except in matters relating to changes in courses of technical instruction and such control by the War Department of personnel of such schools as may be necessary to carry out properly the prescribed courses of instruction, with keeping the records of personnel in the Signal Officers Reserve and Enlisted Reserve Corps of the aviation section, Signal Corps, with instruction and equipment of all tactical units of heavier-than-air and lighter-than-air craft, with preparation of requisitions for proper supply of new air units both in the Regular Army and the reserve of the Regular Army, with plans for the creation of new air units in the Regular Army and reserve and with all other matters affecting the aeronautical service. General supply depots and experimental stations so designated in orders of War Department and matters relating to changes in personnel and courses of technical instruction at United States Army aviation and balloon schools within the department are excepted from control and supervision of the aeronautical officer.

General Requirements for Schools

The civilian aeronautical schools will be those approved by the War Department as to instructors, equipment and character of instruction to be given. They will be inspected to determine whether these requirements are fulfilled. Before assignment to a civilian school students will be subjected to an examination.

Pay for Tuition

Each aviation school will be given a certain compensation for instruction of such personnel assigned thereto in amount to be determined upon by the War Department and the proprietor of the school for each aviation student who qualifies for the preliminary flying test. This amount will be paid when the student satisfactorily completes the course. For each aviation student who graduates from a civilian school as a reserve military aviator an additional sum jointly to be decided upon by the War Department and the proprietor will be paid to the school. Upon qualification in the preliminary flying test a student may at the option of the War Department be transferred to a Government school for advanced training or be permitted to complete his training at the civilian school.

Character of Instruction

The course of instruction will be divided into two stages. The first stage will include instruction and qualification through and to include the preliminary flying test. This test will be held under the supervision of an officer or agent of the aviation section of the Signal Corps. The second stage, which is optional with the school authorities, will consist of advanced training necessary to qualify an aviation student as a reserve military aviator. An advanced training type of machine will be used at least during the last stages of this instruction. Detailed information as to the course to be followed in this stage will be furnished the school authorities. The reserve military aviator test will be held under the supervision of an officer or agent of the aviation section of the Signal Corps.

Preliminary Flying Test

(1) Three sets of figure eights around pylons 1,000 feet apart. In making turns around pylons all parts of machine will be kept within a circle whose radius is 800 feet.

(2) Stop motor at a minimum height of 300 feet and land causing machine to come to rest within 150 feet of a previously designated point.

(3) An altitude test consisting of rising to a minimum height of 1,000 feet.

(4) Glides with motor throttled, changing direction 90 deg. to right and left.

NOTE.—(1) and (2) may be executed in one flight, (3) and (4) in one flight. The same rules apply in starting from and landing on water. Special attention will be paid to the character of landings made.

Should any aviation student desire to take the pilot license test prescribed by the International Aeronautic Federation, facilities will be afforded him.

Report of these tests will be submitted to the officer in charge of the aviation section, with the information as to whether or not the school will complete the training of the aviator through the reserve military aviator stage.

If the preliminary flying test is passed satisfactorily and a candidate qualifies in other respects he will be eligible for further instruction to qualify as a reserve military aviator.

Reserve Military Aviator Test

Reserve military aviator test will be as follows:

(1) Climb out of a field 2,000 feet square and attain 500 feet altitude, keeping all parts of machine inside of square during climb.

(2) Glides at normal angle with motor throttled. Spirals to right and left. Change of direction in gliding.

(3) At 1,000 feet cut off motor and land within 200 feet of a previously designated point.

(4) Land over an assumed obstacle 10 feet high and come to rest within 2,500 feet from same.

(5) Cross-country triangular flight of 30 miles, passing over two previously designated points. Minimum altitude 2,500 feet.

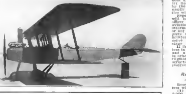
(6) Straight away cross country flight of 30 miles. Landing to be made at designated destination. Both outward and return flight at minimum altitude of 2,500 feet.

(7) Fly for 45 minutes at an altitude of 4,000 feet.

If in addition to the preliminary flying test the candidate also passes the reserve military aviator's test satisfactorily, he will be given a commission in the aviation section, Signal Officers Reserve Corps, provided all other qualifications are fulfilled.

All candidates for the aviation section, Signal Officers Reserve Corps, will be required to pass the prescribed physical examination, must weigh not more than 190 pounds stripped, must furnish evidence of having a college education or its equivalent and be of good moral character.

Applicants for commissions as reserve officers who hold the pilot certificate of the International Aeronautic Federation may, after successfully undergoing the prescribed examinations, be given a flying examination embodying at least the requirements of the preliminary flying test. If competent they may also take the reserve military aviator's test.



To encourage and increase aviation training, Government officials have authorized the sale to private parties of Standard Model J Primary Training machines built for the Government to full specifications, and passed by Government inspectors. The J has a high factor of safety and is equipped with a special safety landing gear, as shown, which prevents nosing over. It has a low landing speed of 37 m.p.h. Several of these machines that have passed Government inspection are now complete and ready for immediate delivery from the Standard Aero factory at Plainfield, N. J. A large number are being built for Government use, thus assuring quick deliveries of spare parts. It is expected by the War Department that the opening of the sale of the machines to private parties will relieve the congestion of men at the training camps, due to lack of machines.

S A E Standards Committee Report

At the meeting of the Standards Committee of the S A E, held in Cleveland last week, the Aeronautic Division, of which C M Manly of The Curtiss Co, is chairman, presented a report, recommending the adoption of certain standards in airplane construction, all the recommendations being subject to the approval of the War Department.

The report, which was read by F S Duesenberg, was accepted by the committee and will be submitted to the membership of the Society at the June meeting and later by letter ballot in accordance with the custom of the Society. It is expected that formal approval of the War Department will be received by that time. The committee and the officers of the Aviation Section are working together with cordial cooperation and the greatest harmony, all being imbued with a full sense of the needs of the country, and the necessity for increasing the output of machines.

The committee's recommendations cover the following items:

1 The adoption of two types of control, the Deperdussin for heavy machines and the stick type for light machines.

2 The use of clincher rims for airplane wheels conforming to the standards of the Clincher Automobile Tire Manufacturers Assn, the rim sizes to be 24 by 3½, 28 by 4 and 32 by 4½. Tires of corresponding sizes are to be used.

3 Marking of fuel and oil pipe lines, fuel lines with red stripes ½-in. wide painted around the pipes and 24 in. apart, and oil lines with circular white rings ½-in. wide and 24 in. apart.

4 The use of the English system of measurement except in such isolated cases as spark plug threads where the metric system is desirable. This action is due to the fact that the army and navy departments are not both in favor of adopting the metric system.

5 The following spark plug dimensions: Thread 18 mm. 1½ mm. pitch. The hexagon is to be 1 in. across flats.

6. Engine rotation to be defined as: "The direction of engine rotation is normal when the final power delivery member of the engine rotates anti-clockwise viewed facing the power delivery end. Opposite rotation is anti-normal."

7 Approval of the following S. A. E. standards for aeronautic practice: Steel specifications, heat treatments, test specimens, ball bearing sizes, throttle levers, magneto dimensions, cotter pin sizes, and screws and bolts.

8 Many other standards relating exclusively to airplane practice were approved, including flexible cable ends, spliced or flexible rods, thimbles, turnbuckles, pipe fittings, propeller hubs, etc.

New Members of the S. A. E.

The following applications for membership in the Society of Automotive Engineers have been approved:

Raymond O Cafland, engineer, Wright-Martin Aircraft Corp., New York.

Ralph H Crosby, chief draftsman of Wright-Martin Aircraft Corp., New York.

Chas C Dodge, sales engineer, Park Drop Forge Co.

Henry Kleckler, chief airplane engineer, Curtiss Aeroplane & Motor Corp., Buffalo, N. Y.

Robert F Runge, production manager, The Hess-Bright Mfg. Co., Philadelphia, Pa.

Elbert J Hall, Vice-President and General Manager, Hall-Scott Motor Car Co., Inc., Berkeley, Cal.

A H Hudson, General Purchasing Agent, Simplex Automobile Co., New Brunswick, N. J., Wright-Martin Aircraft Corp., New York City.

Thos. H Huff, instructor in aeronautics, Massachusetts Institute of Technology, Cambridge, Mass. Assistant Aeronautical Engineer, Sturtevant Aeroplane Co., Jamaica Plain, Boston, Mass.

Chester Huntington, Secretary and Treasurer, Huntington Aircraft Co., New York.

Howard Huntington, President and Construction Engineer, General Aircraft Co., President and Manager, Huntington School of Aviation, New York.

Harry A Miller, Owner and Chief Engineer, Harry A Miller Mfg. Co., Los Angeles, Cal.

John Joseph Rooney, Aeronautical Engineer, Wright-Martin Aircraft Corp., New York.

Russell B Shaw, Designing Engineer, Wright-Martin Aircraft Corp., New York.

Richard M Vanbrink, Chief Designer, Hall-Scott Motor Car Co., Berkeley, Cal.

T Yu, Aeronautical Engineer, The Curtiss Aeroplane Co., Buffalo, N. Y.

Curtiss Engine Makes Splendid Run

N B. Robbins instructor in the Army School at San Diego, Cal, states in a recent letter that the 8-cylinder, V type, "OX" Curtiss engine used by him has run officially for 127 hours without over hauling He added that he expected to get from 150 to 175 hours flying service out of the engine without taking it out of the machine Mr Robbins writes

This engine I refer to is in machine No 187 —Curtiss JN used for training by myself Is now in perfect working order Turns the propeller now at 1425 r p m I believe I would be safe in saying that the average is about 1400 for this type and size engine Some time ago a congressional committee visited the school and we flew in review with about 20 machines. On this trip I piloted my machine without student and attained an altitude of 3,700 feet in just 7 minutes, this with the engine referred to, and at that time it had run about 100 hours.

All Hess-Bright Stock Now American Owned

In line with plans made last autumn when certain New York interests, including the National City Bank and Brown Bros, who were previously interested in the S K F Ball Bearing Co, also acquired an interest in the Hess-Bright Manufacturing Co, of Philadelphia, it is announced that plans have been perfected for a closer cooperation between these two large concerns in the ball bearing industry

The affairs of the two companies will be administered by a recently formed corporation The S K F Administrative Co of No One Wall Street The board of this company consists of Frank A Vanderlip president of the National City Bank Thatcher Brown of Brown Bros, F B. Kirkbride S Wingquist, Axel Carlander, Marcus Wallenberg, a well known banker of Sweden, and B G Prytz, who as president of the S K F Ball Bearing Co, has been active in bringing about the fusion between his company and the Hess Bright Co Mr Prytz has been elected president of the Administrative Co Budd D Gray, of the Hess-Bright Co has resigned as president and will become technical advisor to the New York corporation B G Prytz has been elected to succeed Mr Gray as president of the Hess Bright Co

The S K F Administrative Co is extending the facilities of both the Philadelphia and Hartford plants. The demand for the company's products continues to be so far in excess of the present supply that it has been considered advisable to immediately make additions both to the S K F and Hess-Bright factories The closer cooperation between the two companies was greatly facilitated by the action of the American Hess Bright stock holders in buying out the German minority interests shortly before the break with Germany, whereby all the stock came into American hands

Wright Field Co. to Establish 10 Landing Fields in Ohio

E A. Deeds, of Dayton Ohio, has announced that the Wright Field Co is establishing a string of 10 aviation landing fields between Columbus and Dayton for a flying course, which will be completed by June 15, and will be offered to the Government for use of army aviators in training Wright and Deeds fields at Dayton, with their hangars and other equipment, are included in the offer

One landing place will be on the old Wright farm, seven miles north of Dayton. Another will be just north of Fairfield, and the third in the outskirts of Springfield.

New President of Wright-Martin

The directors of the Wright-Martin Aircraft Corporation met on Friday, May 11th, and elected John F. Alvord president of the company.

Frank H. Russell Elected President of Aircraft Mfgrs.' Association

At the regular monthly meeting of the Aircraft Manufacturers' Association May 9 Harry Bowers Mingle resigned as president of the Association. Mr Mingle said that the expanding business of the Standard Aero Corporation, together with his other interests, made it impossible for him to give the necessary time to the duties of the office The directors, in accepting Mr Mingle's resignation, presented him with engrossed resolutions of appreciation for his services to the Association of which he will continue an active member He was also presented with a handsome gold watch, suitably engraved, as a mark of personal esteem

The election of permanent officers resulted as follows

President, Frank H Russell, of the Burgess Co Marblehead Mass, vice-president and Assistant Treasurer Albert H Flint, of the L. W F Engineering Co., College Point N Y Treasurer, Inglis M Uppercu, of the Aeromarine Plane & Motor Co. New York City, Secretary Benjamin M Williams New York City

The following committees were appointed:

Advisory Patents Materials, Membership, Standardization and Publicity Advertising and Censorship.

It was decided to create a design typifying the aircraft industry, to be used as a distinguishing mark by the Association

The next meeting will be held June 13

New Aviation Club Formed

At a meeting at the Easton, Pa Board of Trade rooms, the Northampton County Aviation Club was organized with T A H Hay as president and George M Shook as secretary It is proposed to purchase one or more airplanes for the use of young men of the county who care to learn to fly It is likely that the aviation field will be the grounds of the Country Club

Victor Carlstrom Victim of Accident

Victor Carlstrom, instructor at the Atlantic Coast Aeronautical School at Newport News, Va, and an army student, Cary B Epes, met instant death on May 9 when their machine broke in the air and fell about 3,500 feet

Several theories are advanced as to the cause of the accident All that is known is that watchers on the ground saw the machine suddenly crumple and then begin an end over end descent. Although one wing had been torn loose and was fluttering down behind the machine, Carlstrom manoeuvred in such a manner as to bring the airplane to its proper position, while he was yet 1,800 feet from the earth He held it in such a position and it struck the ground right side up However, the loss of the wing made it impossible to glide, and the machine shot almost straight downward, burying its nose more than three feet in the ground.

Carlstrom's last act was to cut off his engine 100 feet above the earth, thus preventing the machine from catching fire when it struck Both bodies were mangled almost beyond recognition

Carlstrom was regarded as one of the most skillful and careful of American pilots, and had the unique distinction of having become an instructor one week after quitting his job as a cowboy on a Colorado ranch to take up aviation. Recently he was commissioned Lieutenant in the United States Flying Corps Reserve He was holder of one world record and several American altitude and long distance flight records He first came into prominence on his flight from Toronto to New York and later made his famous attempt at a non stop flight from Chicago to New York

Mr Epes who was formerly a teller in a Newport News bank, resigned to offer his services to the nation on the declaration of war with Germany and was making his first flight

The death of Victor Carlstrom is not only a cause of sorrow among his legion of friends, but is a great loss to American aeronautics.

New Engine Test Room of the Wisconsin Motor Mfg Co., Milwaukee, Wis. The Entire Equipment Is Electrical

Earl S Dougherty Who Is Starting a Flying School at Long Beach Cal., and His Machine Which Is Equipped With a New Variable Pitch Propeller Invented by Robert I. Eustis and Seth Hart The Propeller Has Been Tested in the Air With Satisfactory Results

R. E Glendinning Appointed Major in Reserve Corps

Robert E Glendinning well known banker of Philadelphia has been appointed a major in the aviation section of the Officers Reserve Corps of the United States

Major Glendinning ranks as the foremost Philadelphian in aviation work and he is also acknowledged to be one of the most active men in the country in promoting the interests of aviation in connection with its use for military service

During last summer he made an inspection of the aviation camps in France and studied the use of the airplane in active service on the Somme front

The founding of the Essington School of Aviation was due largely to the interest taken in the project by Major Glendinning During the Spanish American War he served with the First City Troop as a commissioned officer

Squantum School Starts Training

The aviation camp at Squantum Mass is ready for use Four seaplanes of Sturtevant, Burgess and Martin makes, are there and Philip Page Doyle Bradford and Clifford L Webster all experienced aviators, will be detailed to the camp These men will be ensigns in the Navy Flying Corps

There will be twenty aviation students thirty mechanics and ten other attendants at the camp A naval officer will be assigned to take command The State has set aside $50 000 to maintain the camp and the land was loaned by the Sturtevant Aeroplane company and the New Haven railroad The railroad owns the property and the Sturtevant company has a lease on part of it

Fisher Offers Speedway to U. S.

Carl G Fisher has made a formal offer to the Army Aviation Section at Washington of the use of the Indianapolis Motor Speedway as a training camp for aviators. The Aviation Section is anxious to accept the offer, but has postponed acceptance pending action by Congress on a bill to provide funds for the establishing of aviation training camps.

J. N. Willys Elected Director of Curtiss Corp

John N Willys has been elected a director of the Curtiss Aeroplane & Motor Corporation He has acquired a large interest in the Curtiss corporation

H. W. Scholl Now with Levett

H W Scholl, formerly sales engineer of the Splitdorf Electrical Co, Newark, N J has joined forces with the Walker M Levett Co, 417 East Twenty third Street, New York, as director of sales.

Mr. Bell Goes with Norma Co.

Norman Bell, formerly sales engineer in the automobile division of the Lunkenheimer Company Cincinnati has joined the Norma Company of America, makers of Norma high precision bearings, in a similar capacity

Army Fliers Make Good Records

Capt. Byron Q. Jones, holder of the world's sustained flight record for pilot and two passengers, ascended 15 000 feet with Colonel William Keely as observer at San Diego recently He came within 1225 feet of equaling the American altitude record, held by Victor Carlstrom

According to press reports American records for altitude were broken at San Diego May 12 by Capt W. A Robertson junior military aviator at the North Island Training School, who reached a height of 17,230 feet The American record, 16,335 feet, had been held by Victor Carlstrom, who was killed recently in a flight at Newport News, Va Capt Robertson had as a passenger on his flight Capt C K Rhinehardt

Two Enlisted Men Killed at Mineola

Privates Ransom H Merritt and Anthony P Spilena of the Aviation Section stationed at Mineola, L. I, were killed on May 7 when a machine they had in the air without authority broke, under the strain of a too sudden flattening out after a dive and fell about 1500 feet The machine was completely wrecked

The facts seem to be that the men were seized with a sudden desire to take a machine up, and while working on one of the airplanes, without permission and without authority and while no one was near enough to prevent started the engine and went up Once in the air, lack of control and possibly a state of mind best described as being "rattled," resulted in such maneuvers as to endanger other machines up at the same time, and it was necessary to recall the other machines, to prevent a collision After some time spent in sharp banking, climbing and diving the machine flattened out suddenly after a long vertical dive, with the result that one of the wings broke and crumpled up, following which the machine dropped to the ground Both men were instantly killed

Press Illustrating Service Inc

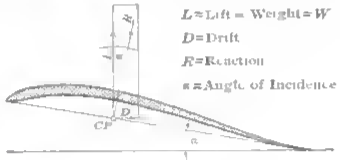
This View of an L. V G Biplane Captured by the Italians Shows Very Clearly the Construction of the 6-Cylinder 180-hp Benz Engine, and the Mounting of the Machine Gun Firing through the Propeller

Horsepower Calculations for Airplanes

[The following calculations, by G. L. in *The Aeroplane*, London, should prove interesting to students of mathematics as well as designers of airplanes.]

The thrust of the propeller depends on the power of the motor, and on the diameter and pitch of the propeller. If the required thrust to a certain machine is known, the calculation for the horsepower of the motor should be an easy matter.

The required thrust is the sum of three different "resistances." The first is the "drift" (dynamical head resistance of the aerofoils), i.e., $\tan \alpha \times$ lift (L), lift being equal to the total weight of machine (W) for horizontal flight and α equal to the angle of incidence. Certainly we must take the $\tan \alpha$ at the maximum A_y value for minimum speed, as then the drift is the greatest (Fig. 1).



$\text{Tan } \alpha = \frac{D}{L}$, $D = \text{Tan } \alpha L$

Fig. 1

Another method for finding the drift is $D = K \times AV^2$, when we take the drift again so as to be greatest.

The second "resistance" is the total head resistance of the machine, at its maximum velocity. And the third is the thrust for climbing. The horsepower for climbing can be found out in two different ways. I first propose to deal with the method, where we find out the actual horsepower wanted for a certain climbing speed to our machine, where

$$\text{H P.} = \frac{\text{climbing speed/sec} \times W}{550}$$

In this case we know already the horsepower for climbing, and we can proceed with our calculation.

With the other method we shall find out the "thrust" in pounds or kilograms wanted for climbing and add it to drift and total head resistance, and we shall have the total "thrust" of our machine and we shall denote it with T, while thrust for climbing shall be T_c.

The following calculation is at our service to find out this thrust for climbing $\frac{V_c \times W}{550} = \text{H.P.}$,

thence $V_c = \frac{\text{H P} \times 550}{W}$ . . . . . (1)

$\text{H P.} = \frac{T_c \times V}{550}$, then from

(1) $V_c = \frac{\frac{T_c \times V}{550} \times 550}{W} = \frac{T_c \times V}{W}$, thence, $T_c = \frac{\text{I.c} \times W}{V}$

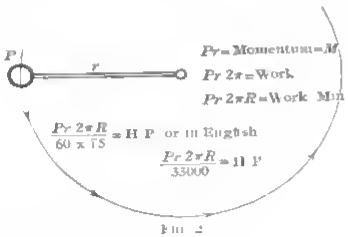


Fig. 2

I consider this method to be more accurate than the previous one, as here the velocity of the machine is included, which is, of course, the minimum speed, to obtain the utmost surplus thrust for climbing.

Whether T means drift, head resistance and thrust for climbing, or drift and head resistance only, the following calculation is the same, only in the latter case, of course, we must add the horsepower required for climbing to the result to obtain the total horsepower.

Now, when we know the total thrust, we shall find the horsepower in the following manner.

We know that the $\text{H P} = \frac{Pr\,2\pi R}{75 \times 60}$ in kilograms or in English measure, $\text{H P} = \frac{Pr\,2\pi R}{33\,000}$ (Fig. II)

where P = pressure in kgs. or lbs.
r = radius on which P is acting
R = Revolution/min.

When $P \times r = M$ then $\text{H P} = \frac{M R\, 2\pi}{4500}$, thence,

$M = \frac{\text{H P}}{R\,2\pi} \frac{4500}{} = \frac{716.2\ \text{H P}}{R}$ in meter kilograms,

or in English system $M = \frac{\text{H P}\ 33000}{R\,2\pi} = \frac{5253.1\ \text{H P}}{R}$ in foot pounds.

Now the power on the circumference of the propeller will be reduced by its radius so it will be $\frac{}{r} - p$. A part of p will be used for counteracting the air and bearing friction, so that the total power on the circumference of the propeller will be $\frac{M}{r} \times \eta - p$ where η is the mechanical efficiency of the propeller. Now $\frac{}{\text{dia } \alpha} - T$ where α is taken on the tip of the propeller.

I take α at the tip, but it can be taken, of course, at any point, but then in equation $p = \frac{M}{r}$, r must be taken only up to this point, and not the whole radius, but it is more comfortable to take it at the tip as $\text{dia } \alpha = \frac{\text{Pitch}}{r\,2\pi}$ (Fig. III).

Now we can write up the equation of the thrust $T = \frac{716.2\ \text{H P.}\ \eta}{R\ r\ \text{tan}\ \alpha}$ or in English measure $\frac{5253.1\ \text{H P}\ \eta}{R\ r\ \text{tan}\ \alpha}$

thence $\text{H P.} = \frac{T \times R \times r\ \text{tan}\ \alpha}{716.2\ \eta}$ or in English measure

$\frac{T \times R \times r\ \text{tan}\ \alpha}{5253.1\ \eta}$

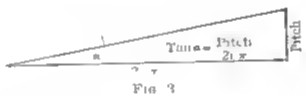
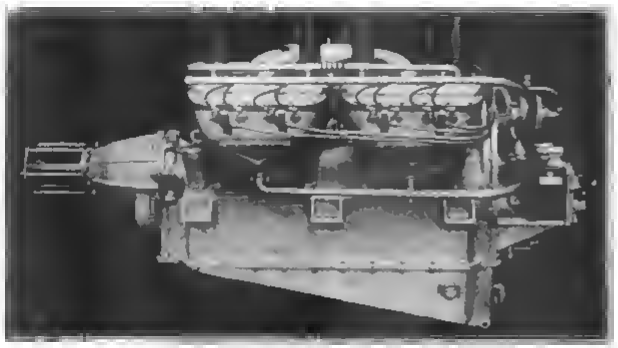


Fig. 3

In my own experience once, when checking the power, via thrust on a small 30 horsepower experimental machine, the spring balance showed 95 kilograms of thrust, and with the above calculation the thrust should be 94.5 kilograms. Such correctness of the calculation is more of a coincidence than anything else, owing to the unreliability of the petrol motors, but always (and I had many trials) the spring balance showed a thrust of 95 to 105 kilograms.

On another machine (50-horsepower) within my experience the spring balance showed 140 to 150 kilograms of thrust, while with the calculation it should be 134 kilograms. I show the above two instances out of the many I could bring, to show that we are always on the safe side with this calculation, as we have always a few horsepower over and above our requirements at our highest speed and our highest climbing velocity.



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This has been accomplished without sacrificing in the least the efficiency or appearance of the machine.

It fills the urgent need found at present in the aviation schools—giving great range of control and allowing the instructor to be at side of the pupil during flight, thereby facilitating instruction.

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By our method of hydraulically forging these cylinders, the metal is closely confined in dies under enormous pressure, which makes same very uniform and dense, and greatly increases the physical properties.

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10 cents a word, minimum charge $2.00, payable in advance. Address replies to advertisements with box numbers, care of AVIATION AND AERONAUTICAL ENGINEERING, 120 West 32d Street, New York.

WANTED—AIRPLANE DESIGNER FULLY EXPERIENCED IN DESIGN AND CONSTRUCTION OF LAND AND WATER MACHINES. STATE EXACTLY EXPERIENCE AND TRAINING IN ENGINEERING DESIGN AND FLYING, ALSO SALARY EXPECTED. ALL COMMUNICATIONS STRICTLY CONFIDENTIAL. BOX 49.

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Aeronautical Trade Directory

AVIATION AND AERONAUTICAL ENGINEERING will furnish information and addresses of all companies listed below. Names of Advertisers in this issue are printed in heavy face type

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Goodyear Tire and Rubber Co.
Janney Steinmetz and Co. (Hydrogen Cylinders)
United States Rubber Co.

BAROGRAPHS AND BAROMETERS
Green, Henry J.
Hausleiter, A.
Sussfeld & Lorch
Taylor Instrument Companies

BATTERIES
Electric Storage Battery Co.

BEARING METALS
American Bronze Co.
Fahrig Metal Co.
Magnolia Metal Co.

CARBURETORS
Miller Carburetor Co.
Stromberg Motor Devices Co.
Wheeler and Schebler
Zenith Carburetor Co.

CLOCKS AND WATCHES
Ingersoll, Robt. H. and Bro.
Chelsea Clock Co.
Depollier, J. & Son
Waltham Watch Co.

CLOTHING
Abercrombie & Fitch
Meyrowitz, E. B. (goggles)
N. Y. Sporting Goods Co.
Rogers, Peet & Co.
Sanders Co.
Spaulding, A. G. & Bros.

COMPASSES
Sperry Gyroscope Co.
Taylor Instrument Companies

DOPE AND VARNISH
Adams & Elting Co.
American Emaillite Co.
Chemical Products Co.
Cleaver, The E. Co.
Dubois Chemical Works
Flexible Compound Co.
National Aeroplane Co.
Pratt & Lambert
Standard Varnish Works
Valentine & Co.
Weeks & Co.

DRIFT INDICATOR
Sperry Gyroscope Co.

DYNAMOMETER
Sprague Electric Works

ENGINE PARTS
Allegheny Forging Co.
Burd High Compression Ring Co.
Doehler Die Casting Co.
Erie Specialty Co.
Fibre Finishing Co.
Gifford, Leland Co.
Gill, P. H. & Sons
Hydraulic Pressed Steel Co.
Levett, Walter M. Co.
Park Drop Forge Co.
Standard Parts Co.
Tutt Pierre Mfg. Co.
Thum Steel & Iron Co.
Williams, J. H. & Co.
Wyman-Gordon Co.

EXHIBITION COMPANIES
The Crane Exhibition Co.
Granberg, Gustav
Miller Aeroplane Co.
Weeks Smalley Co.

FABRICS
Courtaulds Mfg. Co.
Lamb, Finley & Co.
McBratney, Robt. & Co.
Scott, Hutchison Co.
Whitman, Clarence & Co.

FIRE EXTINGUISHERS
Fyr Fyter Co., The
Johns Manville Co., H. W.
Pyrene Mfg. Co.

GASKETS
Fibre Finishing Co.

GLUE
Ferdinand, L. W. & Co.
Hoyle & Atkinson

GAGES
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Foxboro Co., The, Inc.
United States Gage Co.

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Ashley Steel Bldg. Co.
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Milliken Bros.
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Radium Luminous Material Corp.

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Berkshire Magneto Corp.
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Splitdorf Electrical Co.

METALS
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Aerial Co. of America (Aluminum Steel)
Bethlehem Steel Co.
Detroit Pressed Steel Co.
Federal Pressed Steel Co.
Garland Ventilator Co.
Gueder, Paeschke & Frey Co.

MODEL AIRPLANES
Ideal Aeroplane Supply Co.
Wading River Mfg. Co.

MOTORCYCLES
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Harley-Davidson Co.
Hendee Mfg. Co.
Henderson Motorcycle Co.

OILS AND LUBRICANTS
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Schweiner & West Mfg. Co.
Washington Aeroplane Co.

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Shore Instrument & Mfg. Co.
Taylor Instrument Companies

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A. Z. Co.
Bush Mfg. Co.
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Livingston Radiator Co.
Rome Turney Radiator & Mfg. Co.
The English & Mersick Co.

SCLEROSCOPE
Shore Instrument & Mfg. Co.

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Pyre Ignition Co.
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Stewart Warner Speedometer Corp.

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Martin Aerodynamic Stabilizer
Sperry Gyroscope Co.

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Christensen, The Engineering Co.
Dayton Engineering Laboratories Co.
Motor Compressor Co.
Northeast Electric Co.
Wagner Hoyt Electric Co.

TACHOMETERS
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Nelson Blower & Furnace Co.
Queen-Gray Co.
Stewart Warner Speedometer Corp.
Veeder Mfg. Co.

TANKS
Janney, Steinmetz & Co.

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Strowger Electric Co.
Telepiograph Corp.
Western Electric Co.

THERMOMETERS
Foxboro Co., The, Inc.
Taylor Instrument Companies

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Goodyear Tire & Rubber Co.
Hodgman Rubber Co.
United States Rubber Co.

TOOLS
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Roebling's Sons, John A. Co.
Simplex Wire and Cable Co.

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American Wireless Tel. Co.
Culling & Washington

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American Balsa Corp.
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Dutton, A. C. Lbr. Corp.
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